L H Moon
& Son
Bookbinders

NATIONAL MUSEUM
OF VICTORIA

RECORDS

OF THE

SOUTH AUSTRALIAN MUSEUM

VOLUME 15

CONTENTS AND LIST OF CONTRIBUTORS

Published by the Museum Board, and edited by the Museum Director

ADELAIDE 1965-1968

Museum Victoria
72054

CONTENTS

No. 1. Published October 6, 1965 Page

Obituary and Bibliography of Herbert Mathew Hale (F. J. Mitchell) 1

Rock engravings and Aboriginal Occupation at Nackara Springs in the North-East of South Australia (Robert Edwards) 9

A Redescription of the Australian Spider Crab "Eurynome granulosa" Baker (Crustacea, Brachyura Majidae) (D. J. G. Griffin) 29

A Revision of the Australian and New Guinea Drymini (Heteroptera-Lygaeidae) (Gordon F. Gross) 39

Chromosomes of Snails Introduced into South Australia and the Northern Territory (Helen M. Laws) 79

Aboriginal Rock Poundings on Gallery Hill, North-Western Australia (Charles P. Mountford) 89

Fishing Rites at Be-Malai, Portuguese Timor (Margaret J. E. King) 109

Two Stone Pestles from Western Papua and their Relationship to Prehistoric Pestles and Mortars from New Guinea (Graeme L. Pretty) 119

Stone Implement Making Among The Nakako, Ngadadjara and Pitjandjara of the Great Western Desert (Norman B. Tindale) 131

A New Species of Holochila (Rhopalocera, Family Lycaenidae) From Victoria and Southern New South Wales (Norman B. Tindale) 165

Notes on some Western Australian Lepidoptera—Rhopalocera with Description of a New Sub-Species of Anisynta albovenata (Frank E. Parsons) 175

The affinities of Tympanocryptis maculosa Mitchell (Lacertilia-Agamidae) (F. J. Mitchell) 179

No. 2. Published December 23, 1966

An Occurrence of Selenite Near Whyalla, South Australia (David W. P. Corbett) 193

New Species of Ologamasus Berlese (Acar:Rhodacaridae) From Australia and New Zealand (David C. Lee) 205

Aboriginal Camp-site on the Sturt River at Coromandel Valley, South Australia (Robert Edwards) 237

Page

Australites Used for Aboriginal Implements in South Australia (Robert Edwards) 243

Zoila marginata (Mollusca, Cypraeidae) in South Australia (Helen M. Laws) 251

The Cytology and Anatomy of Oxychilus alliarius (Miller) (Mollusca, Zonitidae), A New Introduction to South Australia (Helen M. Laws) 257

Neanurid Collembola of Australia Preserved in the South Australian Museum (Riozo Yoshii) 261

Aradidae in the South Australian Museum, Adelaide (Hemiptera-Heteroptera) (Nicholas A. Kormilev) 275

Archaeological Stone Implements from a Lagoon Bed Kangaroo Island, South Australia (H. M. Cooper) 309

Notes on Some Opisthobranches Mainly From South Australia (Robert Burn) 330

Short Notes: Three Fishes Previously Unrecorded from South Australia (C. J. M. Glover) 353

Short Notes: Observations on Endoparasitic Leeches Infesting Frogs in New Guinea (M. J. Tyler, F. Parker, and R. N. H. Bulmer) 356

Short Notes: A Bizarre Refuge for Some Australian Leptodactylid Frogs (Graeme L. Pretty and Michael J. Tyler) 360

No. 3. Published December 21, 1967

Rock Engravings from the Orroroo District South Australia (H. E. Burrows) 363

Aboriginal Cave Paintings, Mount Creek Water Hole, St. Vidgeon, Northern Territory of Australia (Charles P. Mountford and Eric Brandl) 371

Studies on the Hairy-Nosed Wombat Lasiorhinus latifrons (Owen 1845) (Peter Crowcroft) 383

Cranial and Mandibular Characters of Modern Mainland Wombats (Marsupialia, Vombatidae) from a Palaeontological viewpoint, and their bearing on the fossils called Pascolomys parvus by Owen (1872) (D. Merrilees) 399

On Sceparnodon ramsayi Owen, 1884, The Selection of a Lectotype, the Clarification of its Type Locality, and on its Identity with Phascolonus gigas (Owen, 1859) (W. D. L. Ride) 419

Page

A New Tertiary Formation and Fauna from the Tirari Desert, South Australia (R. A. Stirton, R. H. Tedford, and M. O. Woodburne) 427

A Review of the Starfish Genus Nectria (Asteroidea; Goniasteridae) (S. A. Shepherd) 463

The Distribution of Introduced Snails in South Australia (D. E. Pomeroy and Helen M. Laws) 483

The Cytology of Salinator solida (Von Martens), Mollusca, Amphibolidae (Helen M. Laws) 495

Heterogamasus Trägårdh (Acari: Rhodacaridae), including the Subgenus Evanssellus Ryke, stat.n. (David C. Lee) 497

Aradidae in the South Australian Museum Adelaide II (Hemiptera-Heteroptera) (Nicholas A. Kormilev 513

Corrections in the Systematic Position of Certain Taxa of the Chalcidoidea and Proctotrupoidea (s.l.)*, with notes on Synonymy (Paul Dessart) 551

Australites from Myrtle Springs Station South Australia (David W. P. Corbett) 561

Short Notes: Cercartetus lepidus (Thomas) an addition to the Fauna of Kangaroo Island (Peter F. Aitken) 575

Short Notes: Distribution and Forms of Zosterops in South Australia (H. T. Condon) 577

Short Notes: Surprising Capture of Quail-Thrush by Barn Owl (H. T. Condon) 579

No. 4. Published November 5, 1968

A Further Description of Large Stone Implements from South Australia (H. M. Cooper) 581

An Archaeological Camp-Site in the Vicinity of Hallett Cove, South Australia (H. M. Cooper) 605

Nomenclature of Archaeological Cultures and Associated Implements in Australia (Norman B. Tindale) 615

Obituary Notice 641

Prehistoric Rock Engravings at Thomas Reservoir, Cleland Hills, Western Central Australia (Robert Edwards) 647

Excavation of Aboriginal Graves at Gidgealpa, South Australia (Graeme L. Pretty) 671

Aboriginal Cave Paintings and Rock Markings at Ingaladdi Rock Shelter, Willeroo, Northern Territory of Australia (Charles P. Mountford and Erhard J. Brandl) 679

Page

Two More Prehistoric Stone Artifacts from Western Papua (Graeme L. Pretty) 693

Honeyeaters Relative to Nectar Feeding on Kangaroo Island (J. Allen Keast and Herbert T. Condon) 699

Additions to the Frog Fauna of South Australia (David S. Woodruff and Michael J. Tyler) 705

A Taxonomic Study of Hylid Frogs of the Hyla lesueuri Complex Occurring in North-Western Australia (Michael J. Tyler) 711

The Shallow Water Echinoderm Fauna of South Australia (Scoresby A. Shepherd) 729

Some Cave-Dwelling Pseudoscorpionidea from Australia and New Caledonia (M. Beier) 757

Catalogue of Meteorites in the South Australian Museum (Excluding Tektites) (David W. P. Corbett) 767

Short Notes: Further Additions to the Fish Fauna of South Australia (C. J. M. Glover) 791

Short Notes: Redescription of Tuckerella spechtae Womersley (Clive D. Jorgensen) 795

Index to Genera and Species 799

LIST OF CONTRIBUTORS

	Page
AITKEN, PETER F.	
Cercartetus lepidus (Thomas) an addition to the Fauna of Kangaroo Island	575
BEIER, M.	
Some Cave-Dwelling Pseudosocorpionidea from Australia and New Caledonia	757
BRANDL, ERHARD J.	
See Charles P. Mountford	679
BRANDL, ERIC	
See Charles P. Mountford	371
BULMER, R. N. H.	
See M. J. Tyler	356
BURN, ROBERT	
Notes on Some Opisthobranchs Mainly from South Australia	330
BURROWS, H. E.	
Rock Engravings from the Orroroo District South Australia	363
CONDON, H. T.	
Distribution and forms of Zosterops in South Australia	577
Suprising Capture of Quail-Thrush by Barn Owl	579
See J. Allen Keast	699
COOPER, H. M.	
Archaeological Stone Implements from a Lagoon Bed, Kangaroo Island, South Australia	309
A Further Description of Large Stone Implements from South Australia	581
An Archaeological Camp-Site in the vicinity of Hallett Cove, South Australia	605
CORBETT, DAVID W. P.	
An Occurrence of Selenite Near Whyalla, South Australia	193
Australites from Myrtle Springs Station South Australia	561
Catalogue of Meteorites in the South Australian Museum (Excluding Tektites)	767
CROWCROFT, PETER	
Studies on the Hairy-Nosed Wombat Lasiorhinus latifrons (Owen 1845)	383
DESSART, PAUL	
Corrections in the Systematic Position of Certain Taxa of the Chalcidoidea and Proctotrupoidea (s.1.)*, with Notes on Synonymy	551

EDWARDS, ROBERT — Page
Rock Engravings and Aboriginal Occupation at Nackara Springs in the North-East of South Australia 9
Aboriginal Camp-Site on the Sturt River at Coromandel Valley, South Australia 237
Australites Used for Aboriginal Implements in South Australia 243
Prehistoric Rock Engravings at Thomas Reservoir, Cleland Hills, Western Central Australia 647

GLOVER, C. J. M.
Three Fishes Previously Unrecorded from South Australia . . 353
Further Additions to the Fish Fauna of South Australia 791

GRIFFIN, D. J. G.
A Redescription of the Australian Spider Crab "Eurynome granulosa" Baker (Crustacea, Brachyura Majidae) 29

GROSS, GORDON, F.
A Revision of the Australian and New Guinea Drymini (Heteroptera-Lygaeidae) 39

JORGENSEN, CLIVE D.
Redescription of Tuckerella spechtae Womersley 795

KEAST, J. ALLEN AND CONDON, HERBERT T.
Honeyeaters Relative to Nectar Feeding on Kangaroo Island . . 699

KING, MARGARET J. E.
Fishing Rites at Be-Malai, Portuguese Timor 109

KORMILEV, NICHOLAS A.
Aradidae in the South Australian Museum, Adelaide (Hemiptera-Heteroptera) 275
Aradidae in the South Australian Museum, Adelaide II (Hemiptera-Heteroptera) 513

LAWS, HELENE M.
Chromosomes of Snails Introduced into South Australia and the Northern Territory 79
Zoila marginata (Mollusca, Cypraeidae) in South Australia . . 251
The Cytology and Anatomy of Oxychilus alliarius (Miller) (Mollusca, Zonitidae), A New Introduction to South Australia 257
See D. E. Pomeroy 483
The Cytology of Salinator solida (Von Martens), Mollusca, Amphibolidae 495

LEE, DAVID C.
New Species of Ologamasus Berlese (Acar:Rhodacaridae) from Australia and New Zealand 205
Heterogamasus Trägårdh (Acra:Rhodocaridae), Including the Sub-genus Evanssellus Ryke stat.n. 397

MERRILEES, D. Page
Cranial and Mandibular Characters of Modern Mainland Wombats (Marsupialia, Vombatidae) from a Palaeontological Viewpoint, and their bearing on the Fossils called Phascolomys parvus by Owen (1872) 399

MITCHELL, F. J.
Obituary and Bibliography of Herbert Mathew Hale 1
The affinities of Tympanocryptis maculosa Mitchell (Lacertilia-Agamidae) 179

MOUNTFORD, CHARLES P.
Aboriginal Rock Poundings on Gallery Hill North-Western Australia 89

MOUNTFORD, CHARLES P. AND BRANDL ERIC
Aboriginal Cave Paintings, Mountain Creek Water Hole, St. Vidgeon, Northern Territory of Australia 371

MOUNTFORD, CHARLES P. AND BRANDL, ERHARD J.
Aboriginal Cave Paintings and Rock Markings at Ingaladdi Rock Shelter, Willeroo, Northern Territory of Australia 679

PARKER, F.
See Michael J. Tyler 356

PARSONS, FRANK E.
Notes on some Western Australian Lepidoptera—Rhopalocera with Description of a New Subspecies of Anisynta albovenata 175

PRETTY, GRAEME L.
Two Stone Pestles from Western Papua and their Relationship to Prehistoric Pestles and Mortars from New Guinea . . 119
Excavation of Aboriginal Graves at Gidgealpa, South Australia 671
Two More Prehistoric Stone Artifacts from Western Papua . . 693

PRETTY, GRAEME L. AND TYLER, MICHAEL J.
A Bizarre Refuge for Some Australian Leptodactylid Frogs . . 360

POMEROY, D. E. AND LAWS, HELENE M.
The Distribution of Introduced Snails in South Australia 483

RIDE, W. D. L.
On Sceparnodon ramsayi Owen, 1884, The Selection of a Lectotype, the clarification of its Type Locality, and on its Identity with Phascolonus gigas (Owen, 1859) 419

SHEPHERD, S. A.
A Review of the Starfish Genus Nectria (Asteroidea; Goniasteridae) 463
The Shallow Water Echinoderm Fauna of South Australia . . 729

Page

STIRTON, R. A., TEDFORD, R. H. AND WOODBURNE, M. O.
A New Tertiary Formation and Fauna from the Tirari Desert, South Australia 427

TEDFORD, R. H.
See R. A. Stirton 427

TINDALE, NORMAN B.
Stone Implement Making Among the Nakako, Ngadajara and Pitjandjara of the Great Western Desert 131
A New Species of Holochila (Rhopalocera, Family Lycaenidae) From Victoria and Southern New South Wales 165
Nomenclature of Archaeological Cultures and Associated Implements in Australia 615

TYLER, MICHAEL J.
A Taxonomic Study of Hylid Frogs of the Hyla lesueuri Complex Occurring in North-Western Australia 711
See Graeme L. Pretty 360
See David S. Woodruff 705

TYLER, MICHAEL J., PARKER, F. AND BULMER, R. N. H.
Observations on Endoparasitic Leeches Infesting Frogs in New Guinea 356

WOODBURNE, M. O.
See R. A. Stirton 427

WOODRUFF, DAVID S. AND TYLER, MICHAEL J.
Additions to the Frog Fauna of South Australia 705

YOSHII, RIOZO
Neanurid Collembola of Australia Preserved in the South Australian Museum 261

A. B. JAMES, GOVERNMENT PRINTER, ADELAIDE

OBITUARY AND BIBLIOGRAPHY OF HERBERT MATHEW HALE

Herbert Mathew Hale, O.B.E., 1895-1963

South Australian Museum Director 1931-1960

Born in North Adelaide on the 3rd June, 1895, into a family essentially interested in business, Herbert Hale followed his secondary schooling at Holdfast Bay and Prince Alfred Colleges with training in accountancy. Although he never completed this course of tertiary study nor did he use it as his chosen profession, it had a guiding influence upon his subsequent career.

Hale had a life-long interest in biology and in April, 1914, he sought the support of Professor Walter Howchin, who had been tutoring him in science, and thereby gained appointment as a science cadet under the then Museum Director, Edgar R. Waite. During thirteen years of close association with Waite he was influenced to specialize in Southern Australian crustaceans in parallel with his Director's interests in the fish fauna of the same region. Part of his early training included participation as junior author with Waite in a "Review of the Lophobranchiate Fishes (Pipe-Fishes and Sea Horses) of South Australia" and his teenage hobby interests in the biology of freshwater fishes and subsequently in the various aquatic invertebrates providing food for aquarium fishes is reflected in his early publications, among which were several outstanding studies of aquatic and semi-aquatic Hemiptera.

Encouraged by Waite and the then Chairman of the Museum Board, Professor T. Harvey-Johnston, Hale was called upon to use his business knowledge and natural organizing ability to an increasing extent, and upon the death of Edgar Waite in 1928 he was promoted to Museum Curator under the direction of the Chairman of the Museum Board. He was elevated to Director in 1931.

His crisp, analytical approach, combined with bustling energy suited him to executive work and by virtue of both his status as Museum Director and his inherent interest in everything relating to the well-being of natural science he played a prominent part in the management of many learned societies and special advisory committees.

In 1962 he was awarded Honorary Life Membership of the Royal Society of South Australia in recognition of 31 years of continuous and prominent service on its Council. The offices which he held included President (1936-37), Vice-President (1934-35, 1937-38) and Treasurer (1938-50), 1953-56). He was also a permanent Vice-President of the Royal Zoological Society of South Australia.

In addition to many cursory appointments, he held two long term Government advisory commissions. In 1925 he was nominated a member of the Flora and Fauna Advisory Committee and in 1937 he was elected Chairman, an office which he held until the Committee was reconstituted in 1962. In 1936 he became a Commissioner of the National Park (subsequently expanded to include control of Wild Life Reserves) and was elected Deputy Chairman in 1955.

A Royal Commission under the chairmanship of R. J. Rudall M.P., was appointed in 1934 to inquire into the fishing industry in South Australia. Hale was included on the three man Commission as scientific adviser. During the following two years he travelled extensively with the Commission gathering data which were presented in three Government reports. Some of the recommendations in these reports have been implemented only recently.

Because of the large museum ethnological collections and widespread local interest in anthropology, he developed an early interest in the life and culture of the aborigines and accompanied many anthropological expeditions. He wrote a number of papers in collaboration with the present Curator of Anthropology, Norman B. Tindale, on the results of these excursions. He was a foundation member of the Anthropological Society of South Australia and was awarded its first Honorary Life Membership in 1957. He was Secretary to the Board for Anthropological Research at the University of Adelaide from 1928-1956 and continued as a member until his death.

In 1928 he was elected to the Handbooks Committee of the British Science Guild (South Australian Branch) and immediately took office as Editor. During his 35 years on the Committee he edited 15 handbooks on South Australian fauna and flora and produced a two-volume text of his own on the "Crustaceans of South Australia" (1927, 1929) which remains a reliable and widely used reference.

The South Australian Museum was founded as the South Australian Institute in 1856, and in record of its first centenary of service to science and education Hale wrote a 225 page illustrated

historical account of the development of the institution, its staff, collections and public displays. This was published as volume 12 of the *Records* of the Museum. The review in *Nature*, February 1957, concludes with the following paragraph which, not only concisely records its scope, but also clearly shows that it achieved its objectives.

> "This is a moving story of a great Museum related in simple language. It is an important contribution to Museum literature not only on account of the elaborate details it relates but also as a record of a large museum and the trials and difficulties which arose and were overcome. It is a record of the acquisition and conservation, despite set-backs, of the present important collections of ethnological, zoological and mineralogical objects and is in many ways an epitome of the history of the museum movement in all parts of the world."

Assisted by a travel grant from the Carnegie Corporation, Hale left Australia on 28th April, 1939 on a study tour of the United States and England in which he planned to study public display methods, and educational techniques, particularly those employing museum material in child education. The onset of the Second World War forced him to curtail his tour and return hurriedly to Australia. Here, financial stringencies prevented him from carrying into effect his plans for an enlarged and modernized museum based on experience gained overseas, and under the frustrations of greatly reduced staff and funds he retired into his laboratory to undertake his most intensive period of taxonomic research.

Using submarine light-trap and other collecting techniques, Hale and several of his colleagues, built up very large collections of small crustaceans from various localities along the southern Australian coast. By systematically describing the Cumacean fauna of Australia on the basis of material selected from this collection, Hale provided a new foundation for the taxonomy of this little known order of crustaceans. His work included the description of a great number of new genera and species as well as considerable reorganization of existing taxa.

Although his outstanding contributions to this and other fields of research were widely recognized and he was awarded the Verco Medal of the Royal Society of South Australia for outstanding "research in science" in June, 1947, I know from personal association with him during his latter years that he valued one commendation above all

others. He looked to the noted British Museum Carcinologist, Dr. W. T. Calman, as the basis of his inspiration, and searching through his papers I found "the letter" of which he had frequently spoken— ". . . I am much interested in your remarkable discoveries in this group (Cumacea), and, if I may be allowed to say so, I think your descriptions and illustrations are models of what such things should be . . .".

Following his retirement on the 30th September, 1960 he maintained an active interest in his investigation of the whale fauna of the Southern Ocean as an Honorary Associate in Zoology and added three papers to an already valuable contribution to research in this field. The manuscript of a further paper was completed just prior to his death on the 3rd September, 1963, and has now been published.

Herbert Hale enjoyed an active life and obtained a great deal of satisfaction from his work. In addition to research, he aligned himself closely with the causes of conservation and the sane management of natural resources, and was instrumental in promoting many successful moves to increase public knowledge and appreciation of our native fauna and flora.

His long and conscientious service to the community was recognized by his inclusion in the New Year Honors List for 1954.

Bibliography

1918. "An Aquarium Heater." Aquatic Life, Philadelphia. Sept. 1918, 13-14 and fig.

1920. "Notes on Mosquito Larvae." Aquatic Life, Philadelphia. Jan. 1920, 9-11, fig. 1-5.
"The Mosquito." Aquatic Life, Philadelphia. Feb. 1920, 18-20, plate.
"The Australian Congolly." Aquatic Life, Philadelphia. Mar. 1920, 25-26, 2 fig.
"The Leafy Sea Dragon." Aquatic Life, Philadelphia. Aug. 1920, 87-88, plate.
"An Australian Catfish." Aquatic Life, Philadelphia. Dec. 1920, 128-129, fig.

1921. "An Enemy of the Breeder." Aquatic Life, Philadelphia. Aug. 1921, 11-12, fig. 1-5.
"Notes on the Forms and Habits of Aquatic Insects. Pt. I." S. Aust. Naturalist, ii(3), 50-55, plate.

1922. "Notes on the Forms and Habits of Aquatic Insects. Pt. II." S. Aust. Naturalist iii(2), 5-8, plate.
"Studies in Australian Aquatic Hemiptera, No. I, (Corixidae)". Rec. S. Aust. Mus. ii(2), 309-330, fig. 338-350.

1923. "The Breeding Habits of the 'Back-swimmer', *Anisops hyperion.*" S. Aust. Naturalist, iv(3), 124-128, fig. I.
"Studies in Australian Aquatic Hemiptera, No. II, (Notonectidae)." Rec. S. Aust. Mus. ii(3), 397-424, pl. x-xi and text fig. 361-373.

1924. "Notes on Australian Crustacea, No. i (Squillidae)." Rec. S. Aust. Mus. ii(4), 491-502, pl. xxxii-xxxiii and text fig. 381-384.

"Studies in Australian Aquatic Hemiptera, No. iii (Nepidae)." Rec. S. Aust. Mus. ii(4), 503-520, pl. xxxiv-xxxvi and text fig. 385-386.

"Aquatic Hemiptera from Groote Eylandt." Rec. S. Aust. Mus. ii(4), 521-522.

"Notes on Australian Crustacea, No. ii (Gnathiidae)." Trans. Roy. Soc. S. Aust., xlviii, 1-6, pl. i-ii.

"Studies in Australian Aquatic Hemiptera, No. iv, (genus *Diaprepocoris*)." Trans. Roy. Soc. S. Aust., xlviii, 7-9, pl. iii.

"The Flora and Fauna of Nuyts Archipelago and the Investigator Group, No. 16, The Crustacea." Trans. Roy. Soc. S. Aust., xlviii, 67-74, pl. iv-v.

"Notes on Australian Crustacea, No. iii (Isopoda-Valvifera from South Australia)." Trans. Roy. Soc. S. Aust., xlviii, 209-226, text fig. 1-10.

"Two New Hemiptera from New South Wales." Proc. Linn. Soc. New South Wales, 461-468, pl. xlvii. (Studies in Australian Aquatic Hemiptera, No. vi.)

"Notes on Eggs, Habits and Migration of some Australian Aquatic Bugs (Corixidae and Notonectidae)." South Aust. Naturalist v, (4), 133-135, pl. and text fig.

1925. "Migration of Water Beetles (*Erctes australis*) at Broken Hill, New South Wales." South Aust. Naturalist vi(3), 43.

"Notes on an Australian Fresh-water Crab (*Gcothelphusa*)." South Aust. Naturalist vi(3), 44-45, plate.

"Notes on Australian Crustacea, No. iv (Astacillidae)." Rec. S. Aust. Mus. iii(1), 33-34, text fig. 16.

"Swedish Scientific Expeditions to Australia 1910-1913. The Aquatic and Semi-Aquatic Hemiptera." Arkiv. Zool. K. Svenska Vet. Akad., 17A(20), 1-20, text fig. 1-8 (Studies in Aust. Aquatic Hemiptera, No. v).

"Observation on the Yabbie (*Parachaeraps bicarinatus*)." Aust. Mus. Mag. ii(8), 271-274, text fig. 1-4.

"Review of Australian Isopods of the Cymothoid group. Part 1." Trans. Roy. Soc. S. Aust., 128-186, text fig. 1-28.

"The Development of Two Australian Sponge-crabs." Proc. Linn. Soc. New South Wales 1(4), 405-414, pl. xxxix-xl and text fig. 1-5.

1926. "Review of Australian Isopods of the Cymothoid group. Part ii." Trans. Roy. Soc. S. Aust. 1, 201-234, pl. xxxvi-xxxvii and text fig. 1-20.

"Habits of the Smooth Pebble-crab (*Philyra laevis*)." South Aust. Naturalist viii(3), 67-69, plate.

"Studies in Australian Aquatic Hemiptera. No. vii (Gymnocerata)." Rec. S. Aust. Mus. iii(2), 195-218, text fig. 81-90.

"Some Aboriginal graves at Adelaide, South Australia." South Aust. Naturalist viii(1), 11, pl. ii-iii.

"Aboriginal Rock Carvings in South Australia." South Aust. Naturalist viii(1), 12.

1927. "The Fauna of Kangaroo Island, South Australia. No. 1—The Crustacea." Trans. Roy. Soc. South Aust. li, 307-321, text fig. 1-7.

"The Crustaceans of South Australia Part 1." Handbooks of the Flora and Fauna of South Australia. (Govt. Printer, Adelaide), 1-210, text fig. 1-202.

1928. "Obituary and Bibliography of Mr. Edgar R. Waite." Rec. S. Aust. Mus. iii(4), 345-360, with portrait (see also Trans. Roy. Soc. South Aust. lii and South Aust. Naturalist ix(2), 21-22.

"The Mexican Axolotl in South Australia." South Aust. Naturalist ix(3), 65-68, pl. i-ii.

"Some Australian Decapod Crustacea." Rec. S. Aust. Mus. iv(1), 91-104, text fig. 19-27.

"Australian Cumacea." Trans. Roy. Soc. S. Aust. lii, 31-48, text fig. 1-17.

1929. "Crustacea from Princess Charlotte Bay, North Queensland. The Isopoda and Stomatopoda." Trans. Roy. Soc. S. Aust. liii, 33-36, fig. 1.

"Notes on the Fauna of Dirk Hartog Island, Western Australia. No. 4—Crustacea." Trans. Roy. Soc. S. Aust. liii, 67-70, pl. v.

"The Crustaceans of South Australia. Part 2." Handbooks of the Flora and Fauna of South Australia. (Govt. Printer, Adelaide), 202-380, text fig. 203-364.

1930. "A remarkable Fresh-water Crayfish (*Parachaeraps bicarinatus*)." South Aust. Naturalist xi(3), 42-43, text fig. 1.

1931. "Beaked Whales—*Hyperoodon planifrons* and *Mesoplodon layardii*—from South Australia." Rec. S. Aust. Mus. iv(3), 291-311, text fig. 1-27.

"The Goose-beaked Whale (*Ziphius cavirostris*) in New Ireland." Rec. S. Aust. Mus. iv(3), 312-313, fig. 1-2.

"The Pigmy Right Whale (*Neobalaena marginata*) in South Australian Waters." Rec. S. Aust. Mus. iv(3), 314-320, text fig. 1-4.

"The Post-embryonic Development of an Australian Xanthid Crab (*Pilumnus vestitus* Haswell)." Rec. S. Aust. Mus. iv(3), 321-332, text fig. 1-17.

"The Future of Australian Fisheries." Progress in Australia, July 7, 10-13, 3 text fig.

1932. "Obituary and Bibliography of Arthur Mills Lea." Rec. S. Aust. Mus. iv(4), 411-432, with portrait.

"The New Zealand Scamperdown Whale (*Mesoplodon grayi*) in South Australian Waters." Rec. S. Aust. Mus. iv(4), 489-496, text fig. 1-10.

"A Cumacean new to South Australia." Rec. S. Aust. Mus. iv(4), 549-550, text fig. 1.

"Tanaidacea and Isopoda collected by the Great Barrier Reef Expedition, 1928-29." Ann. Mag. Nat. Hist. xi(10), 557-562, text fig.

1935. "The Egg-case of a Cat Shark, *Scyliorhinus vincenti* (Zietz)." Rec. S. Aust. Mus. v(3), 367-368, fig. 1.

"Some Aquatic Hemiptera from Western Australia." Trans. Roy. Soc. S. Aust. lix, 249-251, text fig. 1.

1936. "Three New Cumacea from South Australia." Rec. S. Aust. Mus. v(4), 395-403, text fig. 1-6.

"Cumacea from a South Australian Reef." Rec. S. Aust. Mus. v(4), 404-438, text fig. 1-23.

1937. "Further Notes on the Cumacea of South Australian Reefs." Rec. S. Aust. Mus. vi(1), 61-74, text fig. 1-9.

"Cumacea and Nebaliacea." B.A.N.Z. Antarc. Res. Exp. 1929-1931. Series B, iv(2), 37-56, text fig. 1-14.

"Isopoda and Tanadiacea." Aust. Antarc. Exped. 1911-14. Sci. Rep. Series C—Zool. and Bot. ii(2), 1-46, text fig. 1-19.

1939. "Some Fishes hitherto unknown from South Australian Waters." South Aust. Naturalist 19(4), 1-5, colour plate and 5 text fig.

"Rare Whales in South Australia." South Aust. Naturalist 19(4), 5-8, 3 text fig.

1940. "Report on the Cymothoid Isopoda obtained by the F.I.S. 'Endeavour' on the coasts of Queensland, New South Wales, Victoria, Tasmania and South Australia." Trans. Roy. Soc. S. Aust. 64(2), 288-304, pl. xvii and text fig. 1-8.

1941. "Decapod Crustacea." B.A.N.Z. Antarc. Rec. Exped., 1929-1931. Series B, iv(9), 257-286, pl. iii, and text fig. 1-16.

"The Smooth Pipe Fish (*Lissocampus caudalis*)." South Aust. Naturalist 21(1), 5, fig.

"A new South Australian Pipe Fish." South Aust. Naturalist 21(2), 10, fig. (*Histiogamphelus gallinaceus.*)

1943. "Notes on two sand-dwelling Cumacea (*Gephyrocuma* and *Picrocuma*)." Rec. S. Aust. Mus. vii(4), 337-342, fig. 1-9.

1944. "Australian Cumacea. No. 7. The Genus *Cyclaspis*." Rec. S. Aust. Mus. viii(1), 63-142., fig. 1-60 (see also Hale, 1928, 1932, 1936, 1937, 1942 and 1943).

"Australian Cumacea. No. 8. The Family Bodotriidae." Trans. Roy. Soc. Aust. 68(2), 225-286, text fig. 1-38.

"Records of the Oblong Sunfish (*Triurus laevis* Pennant) from South Australia." South Aust. Naturalist 22(4), 1-2, text fig. and cover photograph.

1945. "A stranded School of Whales (*Pseudorca crassidens*)." South Aust. Naturalist 23(1), 15-17, 3 text fig. and plate on cover.

"The Green Turtle (*Chelone midas* Linn.) in South Australia." South Aust. Naturalist 23(2), 9, photograph on cover.

"Australian Cumacea. No. 9. The Family Nannastacidae." Rec. S. Aust. Mus. viii(2), 145-218, text fig. 1-49.

"Australian Cumacea. No. 10. The Family Leuconidae." Trans. Roy. Soc. S. Aust. 69 (1), 85-96, text fig. 1-6.

"Australian Cumacea. No. 11. The Family Diastylidae (part 1)." Trans. Roy. Soc. S. Aust. 69(2), 173-212, text fig. 1-26.

"Australian Cumacea. No. 12. The Family Diastylidae (part 2). *Gynodiastylis* and related genera." Rec. S. Aust. Mus. viii(3), 357-444, text fig. 1-60.

1946. "Australian Cumacea. No. 13. The Family Lampropidae." Trans. Roy. S. Aust. 70(2), 177-188, text fig. 1-4.

"Isopoda-Valvifera." B.A.N.Z. Antarc. Res. Exped., 1929-1931. Series B, v(3), 161-212, text fig. 1-30.

1947. "The Tasmanian or Real Trumpeter in South Australia." (*Latris lineata* Block and Schneider.) South Aust. Naturalist 24(2), ii, text fig.

"Evidence of the Habit of Oral Gestation in a South Australian Marine Fish (*Apogon conspersus* Klunzinger)." South Aust. Naturalist 24(3), 1-3, plates on cover.

"The Pigmy Sperm Whale (*Kogia breviceps* Blainville) on South Australian Coasts. Part 1." Rec. S. Aust. Mus. viii(4), 531-546, pl. xiv-xviii and text fig. 1-17.

1948. "Australian Cumacea. No. 14. Further Notes on the Genus *Cyclaspis*." Rec. S. Aust. Mus. ix(1), 1-42, text fig. 1-21.

1949. "Australian Cumacea. No. 15. The Family Bodotriidae (contd.)." Rec. S. Aust. Mus. ix(2), 107-125, text fig. 1-9.

"Australian Cumacea. No. 16. The Family Nannastacidae (contd.)." Rec. S. Aust. Mus. ix(2), 225-246, text fig. 1-12.

1951. "Australian Cumacea. No. 17. The Family Diastylidae (contd.)." Rec. S. Aust. Mus. ix(4), 353-370, text fig. 1-10.

1952. "Isopoda: Families Cymothoidae and Serolidae." B.A.N.Z. Antarc. Res. Exped. 1929-1931. Series B, vi(2), 21-36, text fig. 1-4.

1953. "Two new Cumacea from South Africa." Trans. Roy. Soc. S. Aust. 76, 45-50, text fig. 1-4.

"Australian Cumacea. No. 18. Notes on Distribution and Night Collecting with artificial light." Trans. Roy. Soc. S. Aust. 76, 70-77, text fig. 1-3.

1956. "The First Hundred Years of the South Australian Museum, 1856-1956." Rec. S. Aust. Mus. xii, i-xii and 1-266, 23 pl. and 6 text fig.

1957. "Der Fetzenfisch, ein seltsames sudaustralisches Seepferdchen." (*Phycodurus eques eques* Gunther). Natur und Volk, Frankfurt a.M. 87(11), 382-385, with plate giving life colouration.

1959. "The Pigmy Sperm Whale on South Australian Coasts. Part ii." Rec. S. Aust. Mus. xiii(3), 333-338, pl. xl and text fig. 1-2.

1962. "The Pigmy Sperm Whale (*Kogia breviceps*) on South Australian Coasts. Part iii." Rec. S. Aust. Mus. 14(2), 197-230, pl. 1-4, and text fig. 1-12.

"Occurrence of the Whale *Berardius arnuxi* in Southern Australia." Rec. S. Aust. Mus. 14(2), 231-244, pl. 5-6, and text fig. 1.

1963. "Young female Pigmy Sperm Whales (*Kogia breviceps*) from Western and South Australia." Rec. S. Aust. Mus. 14(3), 561-577, pl. 36-41 and text fig. 1-11.

1964. "The Pigmy Right Whale (*Caperea marginata*) in South Australian Waters. Part 2." Rec. S. Aust. Mus. 14(4), 679-694, pl. 48, text fig. 1-4, 1 map and tables 1-2.

Collaborative Studies

Edgar R. Waite and Herbert M. Hale (1921): "Review of the Lophobranchiate Fishes (Pipe-fishes and Sea-Horses) of South Australia". Rec. S. Aust. Mus. i(4), 293-324 and text fig. 39-56.

Herbert M. Hale and Norman B. Tindale (1925): "Observations on Aborigines of the Flinders Ranges, and Records of Rock Carvings and Paintings". Rec. S. Aust. Mus. iii(1), 45-60, pl. ii-v and text fig. 18-22.

Herbert M. Hale and Paul S. Hossfeld (1927): "Meteorological Notes". South Aust. Naturalist ix(1), 14-16, 3 fig. (A lightning-struck tree and some unusual hailstones.)

Frank A. McNeill and Herbert M. Hale (1927): "A Lilliputian Marine Battle". Aust. Mus. Mag. iii(4), 129-131, 6 text fig.

Herbert M. Hale and Norman B. Tindale (1929): "Further Notes on Aboriginal Rock Carvings in South Australia". South Aust. Naturalist x(2), 30-34, pl. 1 and text fig. 1.

Herbert M. Hale and Norman B. Tindale (1930): "Notes on some Human Remains in the lower Murray Valley, South Australia". Rec. S. Aust. Mus. iv(2), 145-218, text fig. 1-249.

Herbert M. Hale and Clarence F. Blewett (1931): "A Threatening Invader—*Ichthyophthirius*". South Aust. Naturalist xiii(1), 1-4, fig. 1.

Herbert M. Hale and Norman B. Tindale (1933): "Aborigines of Princess Charlotte Bay, North Queensland. Part i". Rec. S. Aust. Mus. v(1), 63-116, text fig. 1-139.

Herbert M. Hale and Norman B. Tindale (1934): "Aborigines of Princess Charlotte Bay, North Queensland. Part ii". Rec. S. Aust. Mus. v(2), 117-172, text fig. 140-250.

R. J. Rudall, H. M. Hale and E. A. Sheridan (1934): "First Progress Report of the Royal Commission on the Fishing Industry (South Australia)". Govt. Printer, Adelaide, 1-7.

R. J. Rudall, H. M. Hale and E. A. Sheridan (1935): "Second Progress Report of the Royal Commission on the Fishing Industry (South Australia)". Govt. Printer, Adelaide, 1-40 and map.

R. J. Rudall, H. M. Hale and E. A. Sheridan (1935): "Final Report of the Royal Commission on the Fishing Industry (South Australia)". Govt. Printer, Adelaide, 1-15.

F. J. Mitchell.

ROCK ENGRAVINGS AND ABORIGINAL OCCUPATION AT NACKARA SPRINGS IN THE NORTH-EAST OF SOUTH AUSTRALIA

By ROBERT EDWARDS

Plates 1-2, and text fig. 1-4

SUMMARY

This paper records a group of rock engravings at Nackara Springs in the north-east of South Australia. The historical evidence of aboriginal occupation of the area is reviewed; the relation of engravings to topography defined; a selection of the designs reproduced and their antiquity discussed. Comparisons are made with engravings from other sites in the same region and maps are provided to show the location of the various sites.

A collection of stone implements, a burial excavated from near the adjacent camp-site, and a cairn of stone slabs on the bank of Nackara Creek are described. The significance of these is considered in relation to the other evidence of former aboriginal occupation.

INTRODUCTION

This investigation of the Nackara Springs was prompted by the knowledge of their permanence as a water supply on the edge of the drainage area of the Manunda and Yunta Creeks, where rock engraving sites had previously been recorded (Basedow, 1914; Mountford, 1929; Mountford and Edwards, 1963 and Edwards, 1964). The association of engravings and permanent water is now established as a constant factor in the occurrence of archaeological sites in this north-east area of South Australia. This led to the examination of Nackara Springs and the finding nearby of the rock engravings and associated camp-site described in this paper.

ABORIGINAL OCCUPATION

It is significant that the owners of sheep stations in the Manunda-Yunta Creek drainage area do not recall any mention of aboriginals living in this particular region at the time their properties were first

settled. The journals of the explorers were consulted for references to this north-east district and it was found that encounters with aboriginals were limited to the fringe of country described as "dreary", "waterless", "wretched", "barren" and "sterile". The first explorer to record these impressions of the north-east was Colonel Gawler (1839), the second Governor of South Australia. In the heat of December, 1839, three years after first settlement, Governor Gawler, accompanied by Captain Charles Sturt and others, set out from the main north-west bend of the River Murray to explore the land to the north. The party soon reached a succession of sandy, waterless plains, broken only by scattered and stunted trees. Mount Bryan was sighted and named and the Porcupine Range (on the present Pitcairn Station) seen in the distance but not examined. These discoveries were made after considerable hardship in the summer heat and at the cost of the life of one of the party, who became lost and was assumed to have perished.

After the expedition left the aboriginals located on the Murray, the only indications of the presence of other natives in the area examined were columns of smoke seen rising from Mount Bryan. On close investigation these camps were found to have been just abandoned. Governor Gawler (1840) expressed the opinion that the few natives he saw along the Murray ". . . very rarely venture upon the Great Plain of the fossil formation, and probably never traverse them in their full extent". Contact between the aboriginals of Mount Bryan and those of the River Murray is evident from the report of the Protector of Aborigines (1844), who was sent to investigate a conflict and reprisals at Mount Bryan Station in October, 1844. This report disclosed that the local aboriginals sometimes made contact with those of the Murray area—probably along the route provided by the Burra Creek (map, fig. 1). Thus, although Gawler may have been correct in his opinion that the Murray natives seldom left their assured food supplies, there was certainly communication with those to the north through the more favourable areas to the north-west of the River.

In 1842, when Colonel Frome (1843a), Surveyor-General of South Australia, led an expedition northward as far as the Black Rock Hills which he so named, he also examined the country discovered by Governor Gawler around Mount Bryan. Shortage of time prevented further progress to the north-east where it was hoped better pasture land would be found.

In the following winter Colonel Frome (1843b) set out for the north again. This time he succeeded in reaching Mount Serle in the Flinders Ranges. One evening, on the outward journey, a camp was made in the Black Rock Hills and several members of the party climbed to the highest point. From this they would have had a commanding view of the Nackara Hills, and Porcupine Range to the south-east (map, fig. 1). Henderson (1843), one of the party, made the following entry in his journal: ". . . a more dreary prospect than we had before us I could not have imagined. The country appears wretched, at least as far as we could see and not a solitary wreath of smoke could be discerned in the blue distance to convince us that it was even inhabited by the wandering savage". This description illustrates the unfavourable impression gained in spite of heavy rains having fallen throughout the journey.

As the party continued northwards into the Flinders Ranges contact was made with the aboriginals on a number of occasions and the smoke from their fires was often visible in the distance. On returning to Mount Bryan on the homeward journey, Colonel Frome decided to explore to the north-east, hoping to discover the good country thought to exist under the Porcupine Range which had been sighted by Governor Gawler and Captain Sturt in 1839, and by Frome himself, both in 1842 and during his push to the north in the following year. It was hoped that the heavy rains which had fallen during the preceding two months would enable the party to penetrate some distance into unexplored country. As they approached the Porcupine Range, however, all trace of water vanished and they found it impossible to proceed; they obviously had not discovered the nearby permanent spring in the Manunda Creek—recorded by the present writer (1964). Colonel Frome and two companions climbed Mount Porcupine (Waite Hill) from which they recorded "a clear view of the horizon in every direction", adding that "a more barren, sterile country cannot be imagined" (Frome, 1843b). "To the southward was the Murray scrub, as level as the ocean; to the east ditto, with a few small hills covered with scrub; to the westward, the distant high land of Mount Bryan with a vast extent of scrub over which we came the day before; and to the north numerous barren ranges" (Henderson, 1843). On descending the hill the party returned, with some difficulty, to Mount Bryan and thence back to Adelaide.

Although the accounts of these explorations contain many references to aboriginals along the River Murray, in the vicinity of Mount Bryan, and the lower Flinders Ranges, no mention is made of

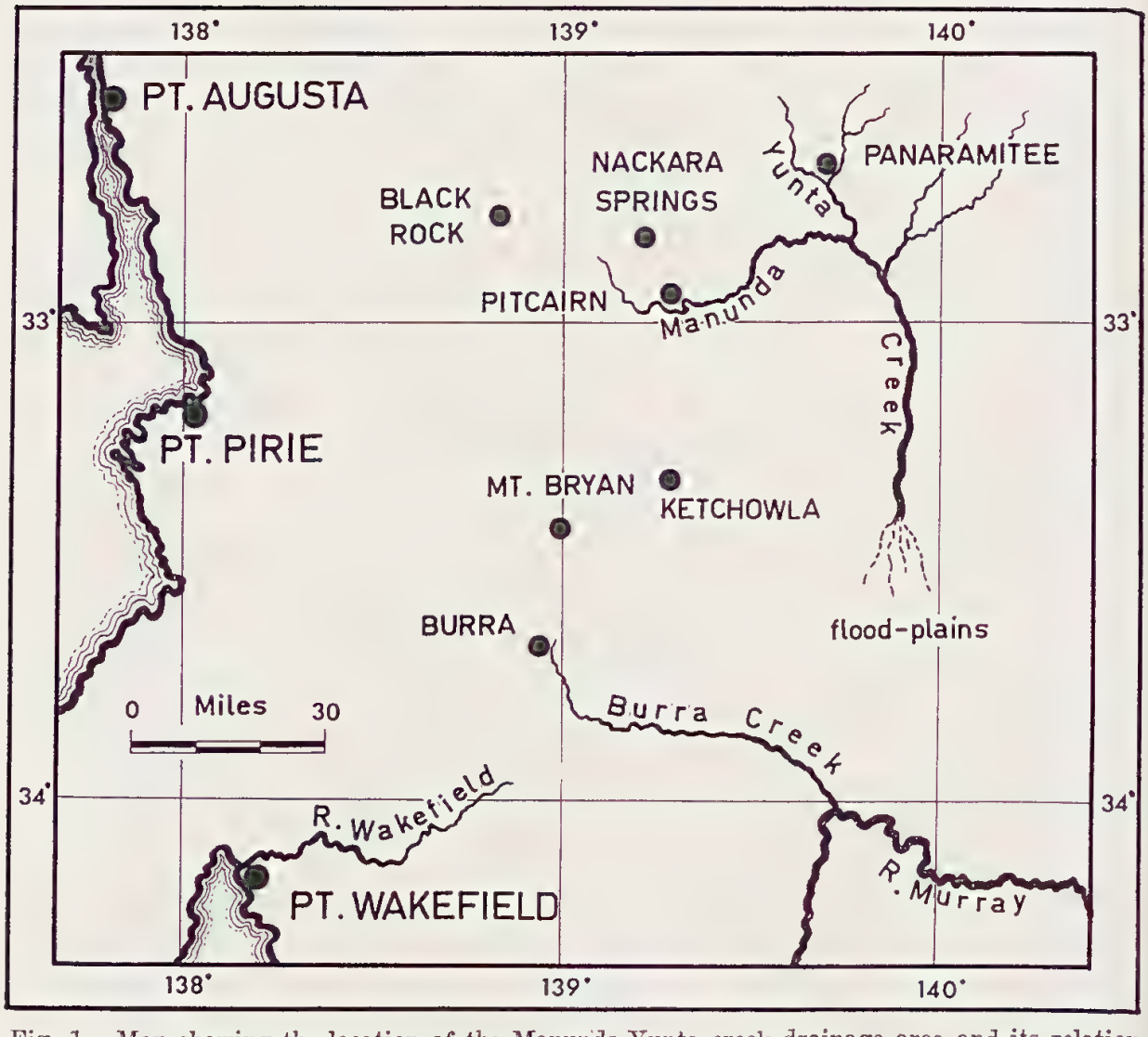


Fig. 1. Map showing the location of the Manunda-Yunta creek drainage area and its relation to the Nackara Springs site.

their presence in the Manunda-Yunta Creek drainage area. The above brief extracts from the available historical records suggest therefore that permanent aboriginal occupation of this region was unlikely at that time.

In spite of the unfavourable reports of this country given by the first explorers, it attracted the attention of pastoralists who, eager to find new land for expansion of their activities, pushed out into the low rainfall area of the north-east to begin a series of costly experiments in raising sheep in a semi-arid environment. In the winter of 1845, Melrose (Cockburn 1925), examined the Nackara area. Local tradition has it that squatters were the first to use the waters of the Nackara Springs. It was not until 1851 that John Williams, notable for his

pastoral activities on the extensive Black Rock Run, extended his holdings to incorporate the Nackara Hills. His pastoral lease (No. 229, of 1st July, 1851) centred around the permanent spring on a tributary of Nackara Creek. Today it is part of a sheep station owned by Mr. N. C. S. Sharkie.

Although the examination of explorers' journals produced little information about the extent of previous aboriginal occupation of these areas, there is ample evidence to show that the country around Nackara Springs had been inhabited or regularly visited by aboriginals.

Environment

Nackara Springs is located in the rugged, hilly country some 165 miles north-east of Adelaide and 30 miles east of Black Rock (map, fig. 1). The Hundred of Nackara was proclaimed in 1880 and for a short time became a Woods and Forests Department reserve for the purpose of preserving the native flora including mallee, sandalwood, native pine, salt bush and blue bush.

The dominating topographical feature near the springs is a conical shaped hill appropriately named "The Cone". Its height is 1,860 feet above sea level. This relatively high area is drained by a complex system of many small creeks. These have cut their way through the hills to the north-west of "The Cone", and join to form a single, large watercourse which, after passing through a small valley and steep-sided gorge, enters the main Nackara Creek (map, fig. 4). When the infrequent thunderstorms bring rain to this semi-arid region, they cause the normally parched creek-beds to become swift-flowing streams and the adjacent countryside to be clothed with natural grasses. Nackara Springs (map, fig. 4, Site A) is a permanent source of water, and, even in times of drought, gives sufficient flow to form a line of rock pools in the watercourse. These have provided pastoralists with a water supply for their sheep for more than a century.

In such semi-arid country, the presence of a permanent spring, together with watercourses and a nearby gorge—to provide soakages—would make this Nackara site highly suitable for aboriginal occupation.

ROCK ENGRAVINGS

Site A

The adjacent sloping ground to the south-west of Nackara Springs rises abruptly to form a series of hills more or less parallel to the main watercourse. A number of these hills are surmounted by rugged

Fig. 2. Rock engraving designs at Site A, Nackara Springs.

outcrops of slaty rock (plate 1A) on which engravings have been made. Although many of these engraved rock surfaces are horizontal, as is customary in the north-east of South Australia, there are a number of instances where engravings have been pecked into inclined and even nearly vertical rock faces (plate 2A).

The designs are, in the main, similar to those recorded from other sites in the surrounding area (Basedow, 1914; Mountford, 1929, 1935; Mountford and Edwards, 1962, 1963; Edwards, 1964). Representations of animal and bird tracks are the most common (fig. 2E, M). There are many circles of various dimensions and combinations (fig. 2C, I, S, T, V), while barred circles (fig. 2O), concentric circles (fig. 2K), engraved dots (fig. 2H, P) and human footprints (fig. 2A) occur less frequently among the designs. Crescents (fig. 2B) and pecked intaglios of lizards (fig. 2D, U) are grouped together in one place—a rare happening on the other sites examined in this north-east area. Two distinctive pecked linear engravings have lines branching from a hole pounded in a sloping surface (fig. 2J, R; plate 1B) while there are smaller examples with lines radiating from a central point (fig. 2L, N). Other abstract designs are shown in fig. 2G, Q.

Site B

The second group of rock engravings in this locality are similar to those found at Site A. There are many animal tracks of different sizes (fig. 3B, C, J, M, V, L, Y), one set of kangaroo tracks (fig. 3A) suggesting a hopping action of the animal. Other kangaroo tracks (fig. 3E and F) may be deliberate attempts to show deformities of the feet of this animal. They are similar to those recorded on a Hill Grange Station site (Edwards, 1964). The circle, in various arrangements (often combined with tracks), forms the basis of many designs (fig. 3B, C, I, M, N, V, W, Y); there are a number of pecked intaglios of human footprints (fig. 3C, M, N, Q, X); a well-executed engraving of five concentric circles (fig. 3K); a small spiral (fig. 3R); an orderly arrangement of eight short bars (fig. 3U); a small snake-like design (fig. 3H) and an elongated barred circle (fig. 3O). Some pecked linear engravings are large geometrical outlines (fig. 3D, I, P, W, Y), while others are indefinite (fig. 3G, S, N, T), and impossible to identify.

There is noticeable variation in rock patination at this site. Many engravings are indistinct and difficult to recognize because water and water-borne sand have eroded the patinated surfaces from some of the rocks. Others on a higher level have retained their dark colour.

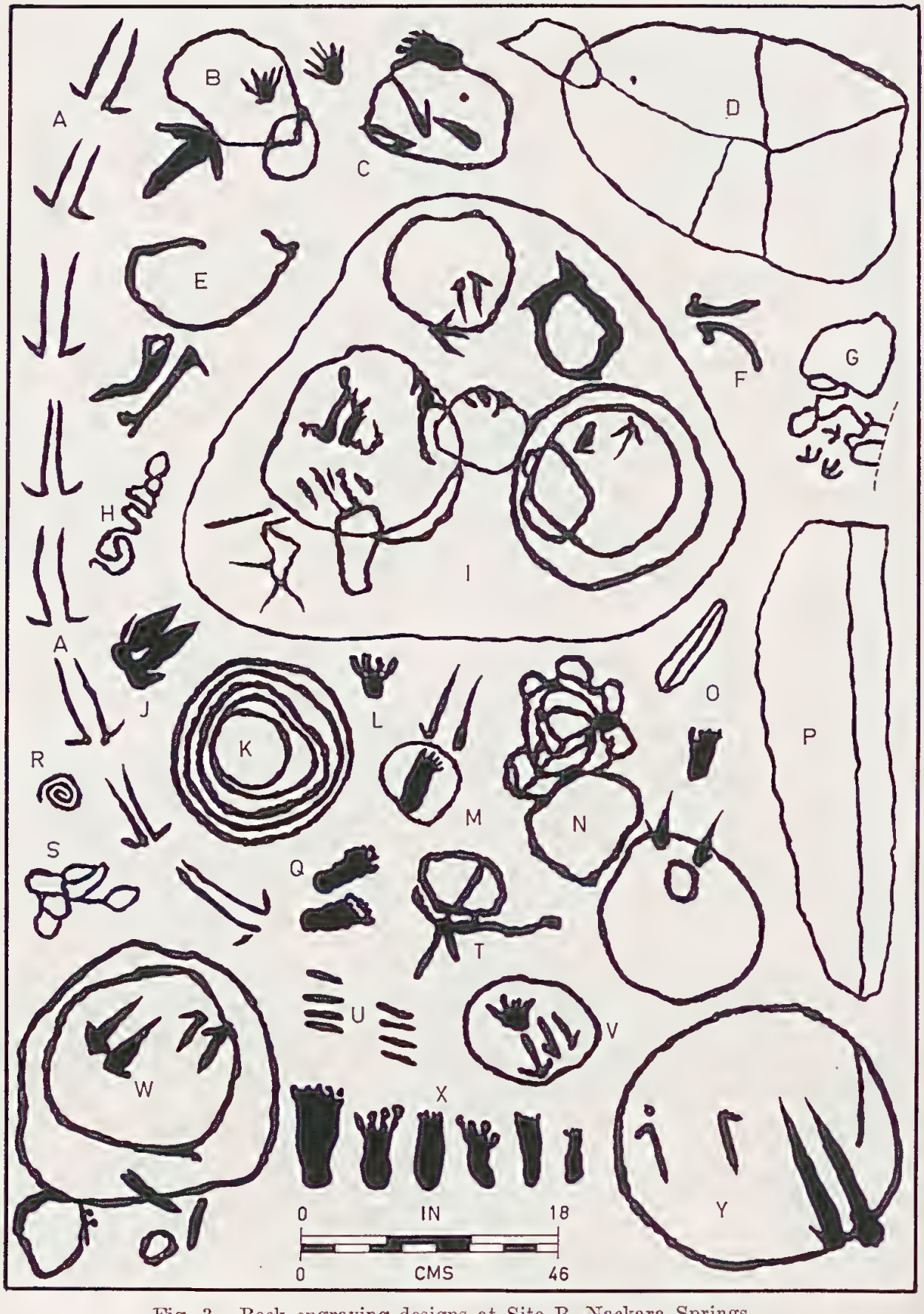


Fig. 3. Rock engraving designs at Site B, Nackara Springs.

The pecking technique employed in making these engravings, the degree of weathering, patination, disintegration of the rocks, absence of engraved tracks of the dingo and the depicting of all the engraved figures in plan, are factors common to the Nackara sites as well as all other groups forming the Manunda-Yunta Creek Series (Edwards, 1964).

"Straight-line" Markings

Markings identical with those recorded at other sites in the north-east of South Australia (Basedow, 1914; Tindale and Mountford, 1926; Mountford, 1929, 1935); at Devon Downs (Hale and Tindale, 1930); Marree (Cooper, 1941); Central Australia (Mountford, 1960) and the Northern Territory (Davidson, 1936; Arndt, 1962), were found to be concentrated on the rocks forming the highest of the hills south-west of the springs. This hill may have been a place of importance in the ceremonial life of the aboriginal as it is the highest of the line and gives a commanding view of the surrounding countryside (plate 1A). Evidence that it was a place of some importance is presented by the remarkable series, amounting to many hundreds, of "straight-line" markings made on the faces and along the ridges of the rocks. These markings, abraded into the rock surfaces, have a striking V-shaped cross-section, deepest in the middle of the depression and tapering to a shallow thin cut at the ends (plate 2B). In length they vary from small grooves of half an inch up to a few large forms of twelve or so inches. A close examination under magnification reveals a number of longitudinal scratches adjacent to each groove. These were apparently formed in the initial attempt to establish a groove of sufficient depth to hold the cutting implement in place. Once a purchase was obtained on the rock surface a repeated to and fro abrading action across the rock produced the groove.

An unrewarding search was made in the vicinity of these engravings for stone implements capable of being used in the production of these grooves. Tindale and Mountford (1926) figure a quartz knife recovered from a camp-site adjacent to similar markings at Morowie. In their opinion this implement was capable of cutting these grooves in the rock surface. The only likely material found at the Nackara site consisted of pieces of the milky variety of quartz which occurs in abundance throughout the north-east region. By experiments with fortuitous pieces of this rock, having sharp edges, it was possible to produce markings identical with those made by the aboriginals.

The action of cutting the grooves caused little damage to the edges of the stone fragments used. A close examination of plastic negative impressions of the grooves shows that the margin of the cutting tool was uneven as minute scratches on the walls of the V-shaped cavities are evident. This gives support to the suggestion that untrimmed quartz fragments were used for making these simple engravings.

The age of these markings is unknown. However, the rock surfaces where they occur at Nackara Springs have been badly fractured through prolonged erosion and weathering; so much so that many pieces with markings occur among the debris on the talus.

As with the pecked intaglios and linear engravings the inner walls of the abraded grooves have adopted the surface colouring of the rock—indicative of long exposure to weathering. Further support of appreciable antiquity is given by Hale and Tindale (1930) who found similar markings on the back wall of the Devon Downs rock shelter at an excavated depth of between ten and thirteen feet. It was suggested that these particular grooves had been formed by the action of sharpening bone tools on the soft limestone (Tindale, 1957).

The origin and meaning of these simple engravings are unknown. Arndt (1962) figures similar markings, known as "rain cuts", from the "Rain Centre" at Delemere, Northern Territory, and records a former associated rain-making ceremony involving singing and dancing after which those taking part each cut a groove in an adjacent rock to make the "Old man bleed and bring rain". This statement is of considerable interest, although as there is no known relationship between these widely separated sites a common meaning cannot be assumed. McCarthy (1958) and McBryde (1964) discuss another form of abraded groove from northern New South Wales which may also be related.

CAMP-SITES

Between the hills with engraved rock surfaces and the Nackara Springs watercourse, the ground has been cut by gutters and generally subjected to erosion by heavy thunderstorm rains. These conditions have contributed to the exposure of groups of hearth-stones and sparsely scattered stone implements of various types. This evidence of aboriginal occupation also extends along the main watercourse as far as its junction with the Nackara Creek.

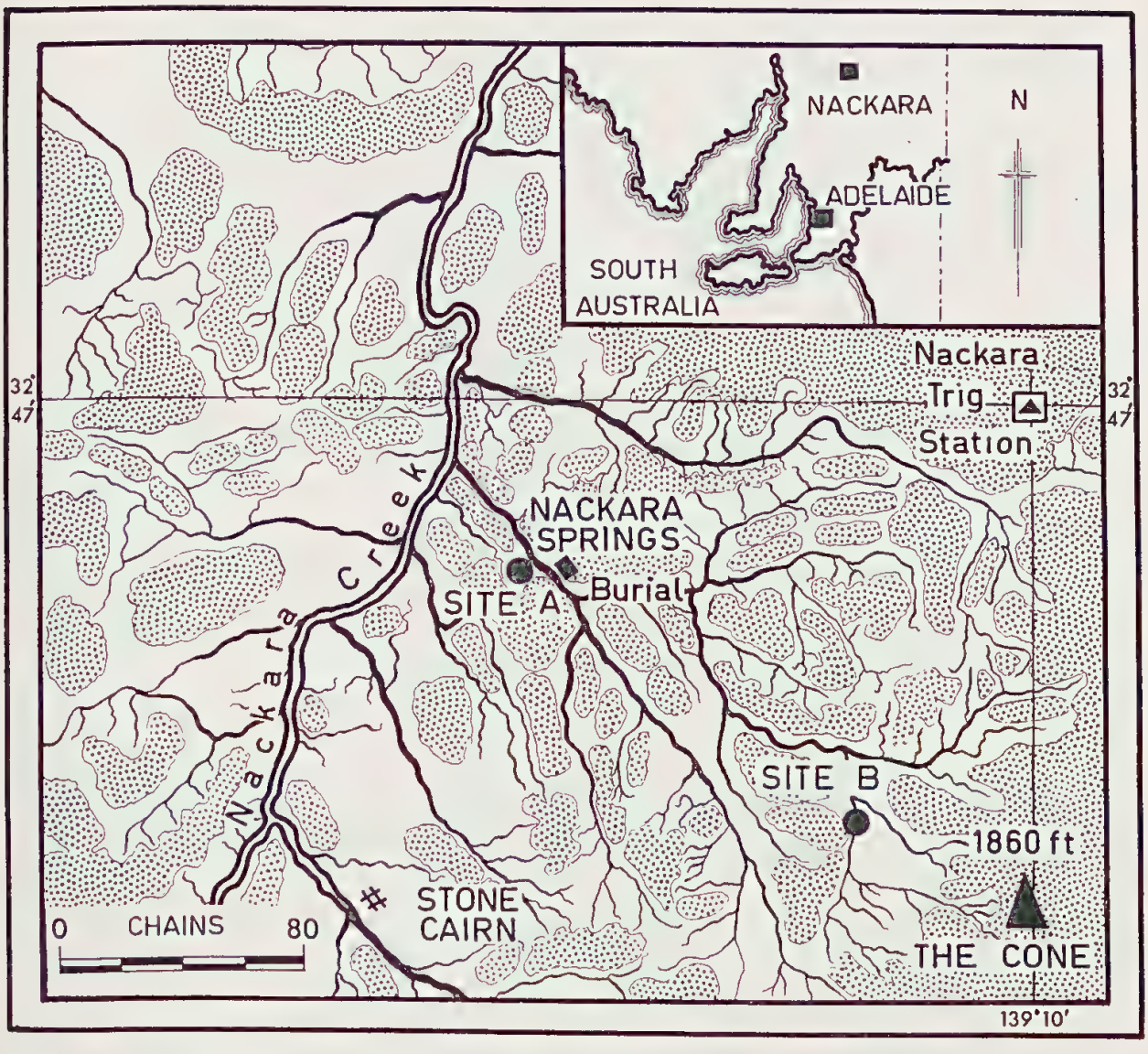


Fig. 4. Detailed map of Nackara Springs area indicating the relative position of rock engravings and camp-sites to the Nackara Creek and other watercourses; shaded areas are elevations above 1,500 feet.

The following stone implements were recovered from this site:— One hundred and eighty-one large trimmed core implements and nineteen large trimmed flakes. Fifty-seven hammerstones; twenty-seven one-sided mill-stones and fourteen double-sided mill-stones. Three hundred and seventy-eight smaller implements were also collected; ninety-five are reduced "tula" flakes; sixty semi-discoids; thirty-seven end "scrapers", ninety-eight irregular shaped flakes with varying amounts of secondary trimming; a small number of nose, double-sided and concave "scrapers"; four blade flakes and twenty-six cores. Out of a collection of forty-eight microliths thirteen are geometrics; ten have end trimming; six are semi-discoids; one discoid;

seven trimmed cores and thirteen working cores. Over five hundred discarded untrimmed flakes were also collected.

Among the material recovered were two complete australites and a discoidal microlith, made from one of these meteoric glass objects. One of the complete specimens of australite is ovate and the other a dumb-bell form. Mountford (1949) and Baker (1957) describe the use the aboriginals made of australites both for ceremonial and magical purposes and for the manufacture of implements. Their presence on this camp-site suggests similar uses.

No artifacts were found near rock engraving Site B.

ABORIGINAL BURIAL

On the north-east bank of Nackara Springs watercourse, erosion had removed about twelve inches of the surface soil exposing a low mound of small stones. Removal of this disclosed a human burial.

Excavation of the upper mound exposed a large flat stone which appeared to have pressed on, and broken in, the back of the skull. After removal of the stone and trowelling away of the soil, the bones were found to be in an advanced stage of disintegration and broke into powdery fragments at the slightest touch. The soil was firmly consolidated around the bones and quite damp, evidently because of soakage from the nearby spring—no rain having fallen for the previous eight months. No natural arrangement of the bones was evident; they appeared to have been separated by pressure of the overlying material. An excavation three feet square and one foot seven inches below the eroded surface was made. It is of interest to note that two geometric microliths were found during the sifting of the soil removed from around the skeleton remains.

Dr. A. D. Packer, of the University of Adelaide, has examined the bone fragments recovered and reports that they "... are of a mature adult aboriginal. There are not sufficient pelvic bone fragments to determine the sex with certainty but the slender cavicales and the appearance of the bones generally suggest that they are from a female. There is nothing to indicate that the remains are other than recent". Professor T. D. Campbell assisted in the removal of the skeleton and examined the remains of the jaw and a number of teeth. In his opinion the shape of the mandible and advanced wear of the teeth showed they were probably of an aged female.

Basedow (1925) describes the mode of burial by the aboriginals of the Flinders Ranges—the corpse was first covered with a layer of foliage and bushes; over this a number of slabs of slate were placed; finally a mound was erected on the site. Although there was no evidence of any decaying vegetable matter in the Nackara Springs grave, the pile of stones removed from the surface and the large stone from over the bones suggest comparison with the burial customs of the Flinders Ranges.

STONE CAIRN

During an examination along the Nackara Creek, a solid cairn about three feet in height was found neatly constructed of flat slabs of local stone (map, fig. 4). This had been erected on the bank of the creek opposite the entry of a large tributary. In its location it could not have been a survey trig and it was unlikely to mark a property boundary.

Arrangements of stones in various forms have been found over a wide area of Australia (Towle, 1939) and many are known to have been made by the aboriginals. Mountford (1940) records stone cairns in the north of South Australia and also at Waroonee and Waukaringa in the north-east. These latter occurrences were of a square hollow construction. Mountford (1940) states that similar stone structures observed in the Northern Flinders Ranges were erected by adolescent boys of the Adnyamatana tribe for "amusement".

There is no evidence to indicate the origin or purpose of this particular example found near Nackara Springs.

DISCUSSION

The rock engravings at Nackara Springs are another of the series of engraving sites associated with the Manunda-Yunta Creek drainage area of the north-east of South Australia.

The engraved figures—their numbers, grouping and distribution—at various sites present to some extent a general pattern of similarity. A comparative study is in progress by means of a quantitative analysis of details of the occurrences. This may reveal some significant related and differing features between the respective sites.

The question of the antiquity of rock engravings in this part of Australia is one which has generally been discussed on the basis of the traditional assessments of the geologist. Conditions so far

presented have not provided associated material amenable to the modern radiocarbon method of age computation. Further investigations may provide a solution for this problem by this means. However, the suggestion of appreciable antiquity is supported by the evidence of the slow processes of decay, fracture and disintegration of the outcropping rocks on which the engravings were made. Many examples are to be seen where these processes have taken place since the engravings were executed; where consequent movement and wide separation of engraved surfaces have occurred; and where detached boulders with engraved designs have fallen down among the talus debris. Also the weathering and patination of the outcrop surfaces and the engravings on them, are possibly processes of appreciable slow development. All these features may indicate a long lapse of time since the engravings were made.

The means by which these engravings were executed have been a matter of conjecture (Edwards, 1964). The apparent absence of suitable stone tools closely associated with the engravings adds to the difficulties. This problem is another undergoing special study by means of close examination of the details of the intaglios under magnification and negative and positive reproductions by means of plaster and modern plastic materials. The evidence so far considered supports the idea that no specialized tool was employed as there is a wide variation in the size of the small pits where particles were removed in the rock surface during the process of making the engravings.

The interpretation of the meanings of the vast array of these engravings is a matter also fraught with difficulties. The observer is confronted with a range of occurrences from a few simple engravings on a rock face to the larger surfaces covered with a confusion of designs, geometric outlines, representations of animal, bird, reptile and human tracks, pecked naturalistic intaglios of animals and "abstract" or indecisive figures. All these vary in size and shape and some designs are superimposed on others. The eroding effects of time and weathering have added to the intricacy of the problem and the difficulty of any attempt at interpretation.

To what extent these sites can be looked upon as having some sacred or ceremonial significance; an association with hunting magic; or how many of the engravings are simply purposeless attempts at expression before magical art developed—are questions difficult to answer. From what has been authoritatively ascertained from other

examples of aboriginal art, such as the designs of rock paintings, carved *tjurunga*—and ceremonial decoration of shields and human bodies, there is no doubt that all these designs, from the simplest to the most complex patterns, had a specific meaning at the time when they were made.

A study of what is accessible and capable of interpretation in present-day aboriginal art is not entirely satisfactory for deciphering these seemingly ancient rock engravings. It would be dangerous to make assumptions or to transpose the meanings given to the designs and figures of cave paintings to often similar figures engraved on rock surfaces. The latter on various viewpoints are usually looked upon as being examples of aboriginal art far predating that expressed in the form of cave paintings. But here again this viewpoint rests on the assumption that rock paintings were not a form of aboriginal art contemporaneous with engravings. It is possible these two forms may have been co-existent, but it seems doubtful whether rock painting in the form of a superficial application of pigments—even if these latter were mineral in constitution—could withstand the effects of time and weather compared with engravings. Some paintings may have been made on open rock surfaces but these, of course, would quickly deteriorate, leaving no trace.

The abraded grooves are an interesting type sometimes associated with pecked intaglios and linear engravings. Occasionally they are concentrated on their own. A number of writers have suggested that these particular engravings were the results of sharpening certain implements of stone or bone. This is an interpretation assuming a definite utilitarian purpose as opposed to any "sacred" significance or artistic expression. It is possible that both the suggested utilitarian and the sacred could have sometimes overlapped—the tool being used gaining some increased magical power through the action of making a groove. The location of this type of engraving in great numbers on the summit of a steep hill at Nackara Springs gave a further opportunity for close examination. As many were on awkward and almost inaccessible rock surfaces and across the narrow angular margins of adjacent rock faces in a wide range of sizes, it is hard to reconcile them with a tool sharpening function. The aboriginal has always been recognized as intensely "practical" and it is difficult to accept that the past aboriginal occupants of this area would climb a steep tor to sharpen his tools when more easily accessible and similar suitable rock outcrops were available at much lower levels.

The many indefinite factors, and probably many others totally unknown, associated with the rock engravings of this area make a complete assessment difficult, and the first stage of the present research must be classification rather than an attempted interpretation. The more detailed and intensive studies now being undertaken may produce evidence of when, why and by whom this interesting series of rock engravings was made.

The stone implements recorded from the Nackara Springs site are tangible evidence of its past occupation although no conclusions are possible from surface finds of this kind. The number of smaller implement types found at Nackara Springs was greater than that recorded from the Pitcairn sites (Edwards, 1964). For example, reduced "tulas", known to have been used mounted on spearthrowers and other wooden handles by aboriginals until recent times, were numerous enough at Nackara (95) to suggest a more regular occupation there than in the semi-arid areas further to the east where only four were found on the three Pitcairn sites.

The burial, the stone cairn, the likeness in implement types and the historical evidence all point to a connection with the Flinders Ranges tribes. It could be that they are the product of excursions and activities of these people into this adjoining easterly region.

Edwards (1964) has described the similarity between the large *Kartan* stone implements found on Pitcairn Station and those collected by Cooper (1943, 1959, 1961) from Hallett Cove, along the River Wakefield, to a limited extent on Kangaroo Island, and on various other sites in South Australia. The large trimmed implements found scattered over the camp-site at Nackara Springs can also be compared with these implements and undoubtedly belong to the same industry. Many of the large implements from Nackara Springs, as elsewhere, have been reduced in size and weight by repeated sharpening—an indication of intensive use. If these *Kartan* implements are old, as has often been suggested, it may be that the aboriginals who made the large implements at Pitcairn Station and those found on the Nackara Springs site, lived at some earlier time and made the rock engravings. It will be necessary however to find a situation where rock engravings and stone implements are located in association with material to which more positive methods of dating can be applied before the pre-history of the area can be confidently reconstructed.

RESUME

Art rupestre, probablement préhistorique, à Nackara Springs, Australie du Sud.

Etude illustrée des gravures, probablement préhistoriques, qui décorent les parois des rochers à Nackara Springs, Australie du Sud. Les sites sont de plein air. Description de l'industrie lithique.

Les gravures, semblables à celles à la confluence Manunda-Yunta Creek, représentent des anneaux et des pistes d'animaux.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of Mr. Brian K. Sawers of Pitcairn Station whose enthusiasm and help made possible this investigation. Mr. N. C. S. Sharkie kindly gave permission to work on his property. Mr. F. K. Archibald assisted in the tracing of the engravings. The advice and practical assistance of Professor G. H. Lawton, Drs. T. D. Campbell and P. S. Hossfeld and Messrs. C. P. Mountford, H. M. Cooper and G. L. Pretty were appreciated. Mr. M. R. Marchant of the South Australian Department of Lands kindly provided the information used in the preparation of the maps.

The Board for Anthropological Research of the University of Adelaide granted funds towards the expenses of field work in this research.

Acknowledgment is also made to the Board of the South Australian Museum for publication of this paper and to Mr. Norman B. Tindale, Curator of Anthropology, for his valuable advice.

REFERENCES

Arndt, W., 1962: The interpretation of the Delemere Lightning Painting and rock engravings. Oceania, Sydney, 32(3).

Baker, George, 1957: The role of Australites in Aboriginal customs. Mem. nat. Mus., Melb., Melbourne, 22(8).

Basedow, H., 1914: Aboriginal rock carvings of great antiquity in South Australia. J. R. anthrop. Inst., London, 44.

——— 1925: *The Australian Aboriginal.* Adelaide.

Cockburn, R., 1925: *Pastoral Pioneers of South Australia.* Vol. 1., Adelaide.

Cooper, H. M., 1941: Rock carvings and other aboriginal relics from near Marree. S. Aust. Nat., Adelaide, 21.

———— 1943: Large stone implements from South Australia. Rec. S. Aust. Mus., Adelaide, 7(4).

———— 1959: Large archaeological stone implements from Hallett Cove, South Australia. Trans. roy. Soc. S. Aust., Adelaide, 82.

———— 1960: The archaeology of Kangaroo Island, South Australia. Rec. S. Aust. Mus., Adelaide, 13(4).

———— 1961: Archaeological stone implements along the Lower River Wakefield, South Australia. Trans. roy. Soc. S. Aust., Adelaide, 84.

Davidson, D. S., 1936: Aboriginal Australian and Tasmanian rock carvings and paintings. Mem. Amer. phil. Soc., Philadelphia, 5.

Edwards, R., 1964: Rock engravings and stone implements of Pitcairn Station, north-eastern South Australia. Rec. S. Aust. Mus., Adelaide, 14(4).

Frome, E. C., 1843a: Report on country to the north of the Light and Gilbert. Despatches, No. 3, South Australian Archives.

———— 1843b: Report of the country to the eastward of Flinders Ranges. South Australian Government Gazette, Sept., 1843, Adelaide.

Gawler, G., 1839: Despatches to the Colonization Commissioners, 1838-41, South Australian Archives.

———— 1840: Notes regarding the Aborigines of the Murray. South Australian Gazette and Colonial Register, 18/1/1840. Adelaide.

Hale, H. M. and Tindale, N. B., 1930: Notes on some human remains in the lower Murray Valley, South Australia. Rec. S. Aust. Mus., Adelaide, 4(2).

Henderson, J., 1843: Narrative of an expedition to Lake Frome in 1843. Manuscript Journal, South Australian Archives.

McCarthy, F. D., 1958: *Australian Aboriginal Rock Art.* Sydney.

McBryde, Isabel, 1964: The linear engravings of the Clarence Valley, Northern New South Wales. Oceania, Sydney, 34(3).

Moorhouse, M., 1844: Letter books of the Protector of Aborigines. South Australian Archives.

Mountford, C. P., 1929: Aboriginal rock carvings in South Australia. Rep. Aust. Ass. Advanc. Sci., Hobart, 19.

——— 1935: A survey of the petroglyphs of South Australia. Rep. Aust. Ass. Advanc. Sci., Melbourne, 22.

——— 1940: Aboriginal Stone Structures. Trans. roy. Soc. S. Aust., Adelaide, 64(2).

——— 1948: *Brown Men and Red Sand.* Melbourne.

——— 1960: Simple Rock Engravings in Central Australia. Man, London, 60.

Mountford, C. P. and Edwards, R., 1962: Aboriginal rock engravings of extinct creatures in South Australia. Man, London, 62.

——— 1963: Rock engravings of Panaramitee Station, north-eastern South Australia. Trans. roy. Soc. S. Aust., Adelaide, 86.

Tindale, N. B., 1957: Culture Succession in South-eastern Australia from Late Pleistocene to the Present. Rec. S. Aust. Mus., Adelaide, 13(1).

Tindale, N. B. and Mountford, C. P., 1926: Native markings on rocks at Morowie, South Australia. Trans. roy. Soc. S. Aust., Adelaide, 50.

Towle, C. C., 1939: A Bibliography of Stone Arrangements found in Australia. Mankind, Sydney, 2(7).

EXPLANATION OF PLATES 1 TO 2

PLATE 1.

Fig. A. General view of Nackara Springs area from summit of the hill where abraded grooves are concentrated.

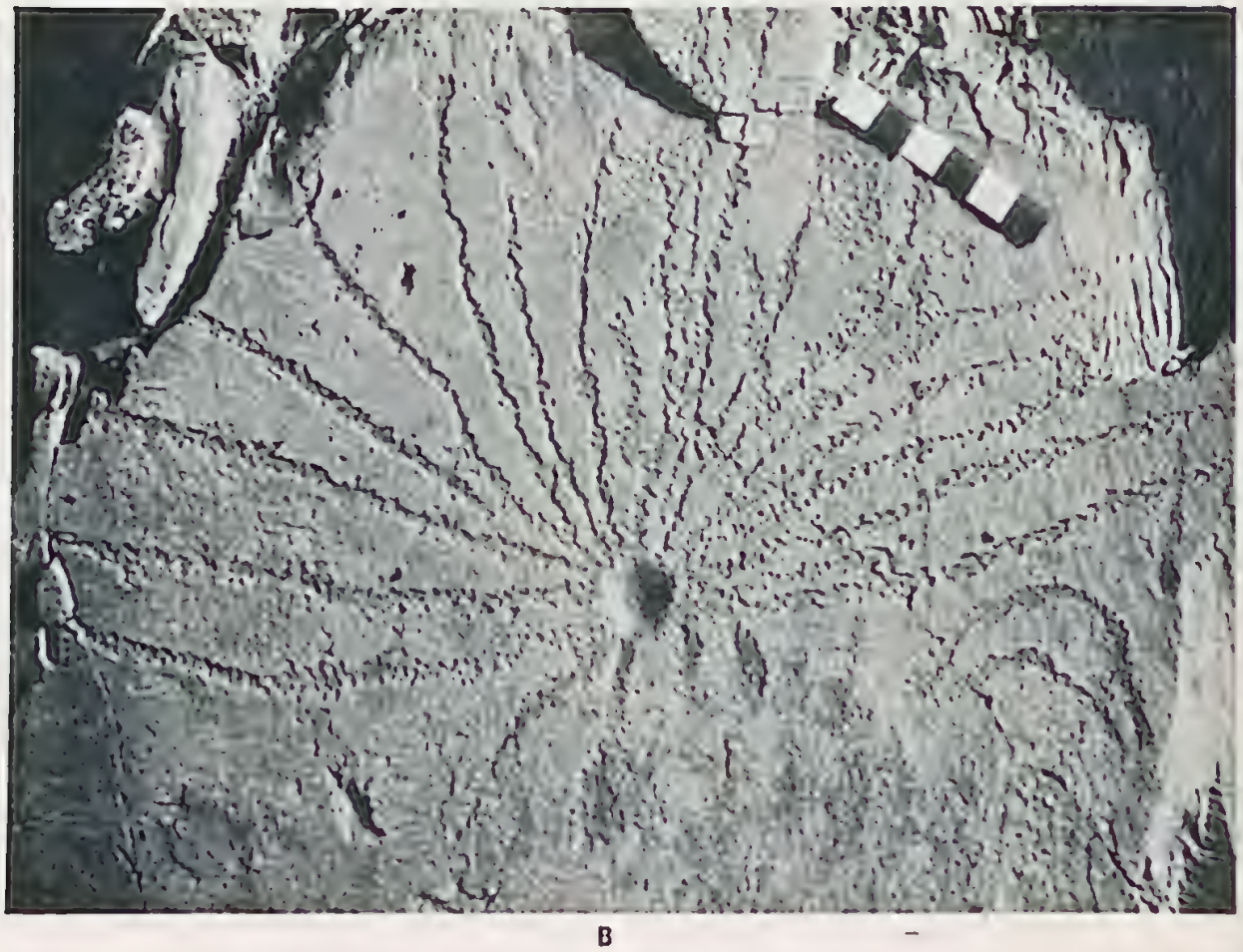
Fig. B. Unusual rock engraving with lines radiating from a small central cup-shaped hollow. Site A, Nackara Springs. Scale in inches.

PLATE 2.

Fig. A. Sloping rock surface engraved with many designs. Site A, Nackara Springs. Scale in inches.

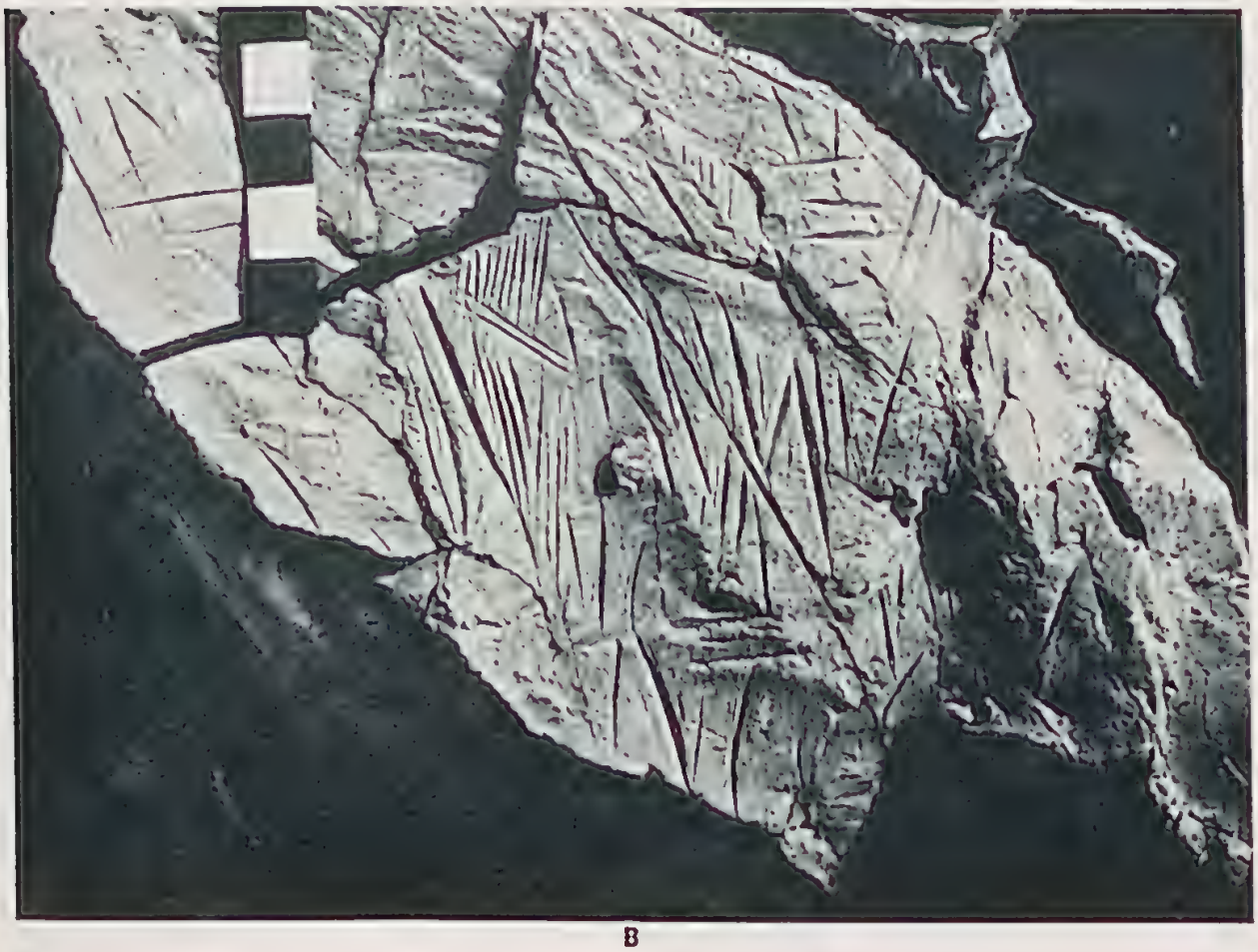
Fig. B. "Straight-line" markings or abraded grooves showing the breaking up of the rocks since the marks were made. Scale in inches.

A



B

A



B

A REDESCRIPTION OF THE AUSTRALIAN SPIDER CRAB "*EURYNOME GRANULOSA*" BAKER (CRUSTACEA, BRACHYURA MAJIDAE)

By D. J. G. GRIFFIN, Zoology Department, University of Tasmania, Australia

Text fig. 1-5

SUMMARY

The majid crab, *Eurynome granulosa*, known only from South Australia, is redescribed and figured from four specimens, including the holotype, and its systematic position discussed. Its numerous similarities to *Chionognathus reini*, a Japanese species, are emphasized. Among the species at present placed within *Eurynome*, *E. granulosa* stands closest to the South African *E. elegans*.

INTRODUCTION

The genus *Eurynome* Leach, at present containing a total of nine species of small majid spider crabs of the subfamily Pisinae, has recently been reviewed and its limits discussed (Griffin, 1964). The genus is distributed throughout the Indo-West Pacific, Mediterranean and East Atlantic, at depths of around 100 fathoms. Characteristically, the carapace in these crabs is pyriform and bears peculiar, flat-topped tubercles, or large spinulated plates, the former arranged in distinct groups and the chelipeds resemble those of a parthenopid crab. However, other equally important characters, such as the number of free segements of the abdomen, details of the orbit and form of the basal antennal article, seem to have been overlooked in a few cases.

Australia is known to possess a single species of the genus, *E. granulosa*, described by Baker in 1906 from a single female dredged in 104 fathoms off the South Australian coast. It has since been figured and briefly described by Hale (1927) but the species is poorly known.

Baker's (1906) original description of *E. granulosa* was detailed but the figures were hardly adequate enough to allow comparison of this species with others at present placed in the genus. The exact form of the third maxillipeds, basal antennal article, supraorbital and

infraorbital margins and ornamentation of the carapace were not made clear, but have an important bearing on the systematic position of *C. reini*. In the present paper *E. granulosa* is redescribed from the holotype and its relationships to the South African *E. elegans* Stebbing, 1921 and to the Japanese *Chionognathus reini* (Balss, 1924) are also considered. The terminology used here follows that of Rathbun (1925) and the system of measurements are those used by Garth (1958).

This study has been made possible by the forwarding to me, through Dr. John Yaldwyn of the Australian Museum, Sydney, of the holotype, and three other specimens of *Eurynome granulosa*, by Mr. F. J. Mitchell of the South Australian Museum, Adelaide. I wish to sincerely thank Mr. Mitchell for allowing me to examine these specimens, Dr. Yaldwyn for helpful discussion and Dr. E. R. Guiler of this Department for reading the manuscript.

SYSTEMATICS

Family MAJIDAE

Subfamily Pisinae Alcock, 1896

Genus *Eurynome* Leach, 1815

Eurynome granulosa Baker, 1906

Fig. 1-5

Eurynome granulosa Baker, 1906: 108, pl. i, figs. 3, 3a. Hale, 1927: 139, fig. 140.

Holotype: Female (S. Aust. Mus. reg. C.1156), carapace length 8 mm. This specimen is dried and in excellent condition with all the appendages present except the second left ambulatory leg and the carpus and following joints of the left third ambulatory leg.

Type locality: South Australian coast, dredged in 104 fathoms; Dr. Vercoe, collector.

Localities subsequently reported: None.

Material examined: In addition to the holotype, the dried carapaces of three other small specimens (S. Aust. Mus. reg. C.1160), 6-8 mm in length, South Australia, 100 fm, no date, no collector.

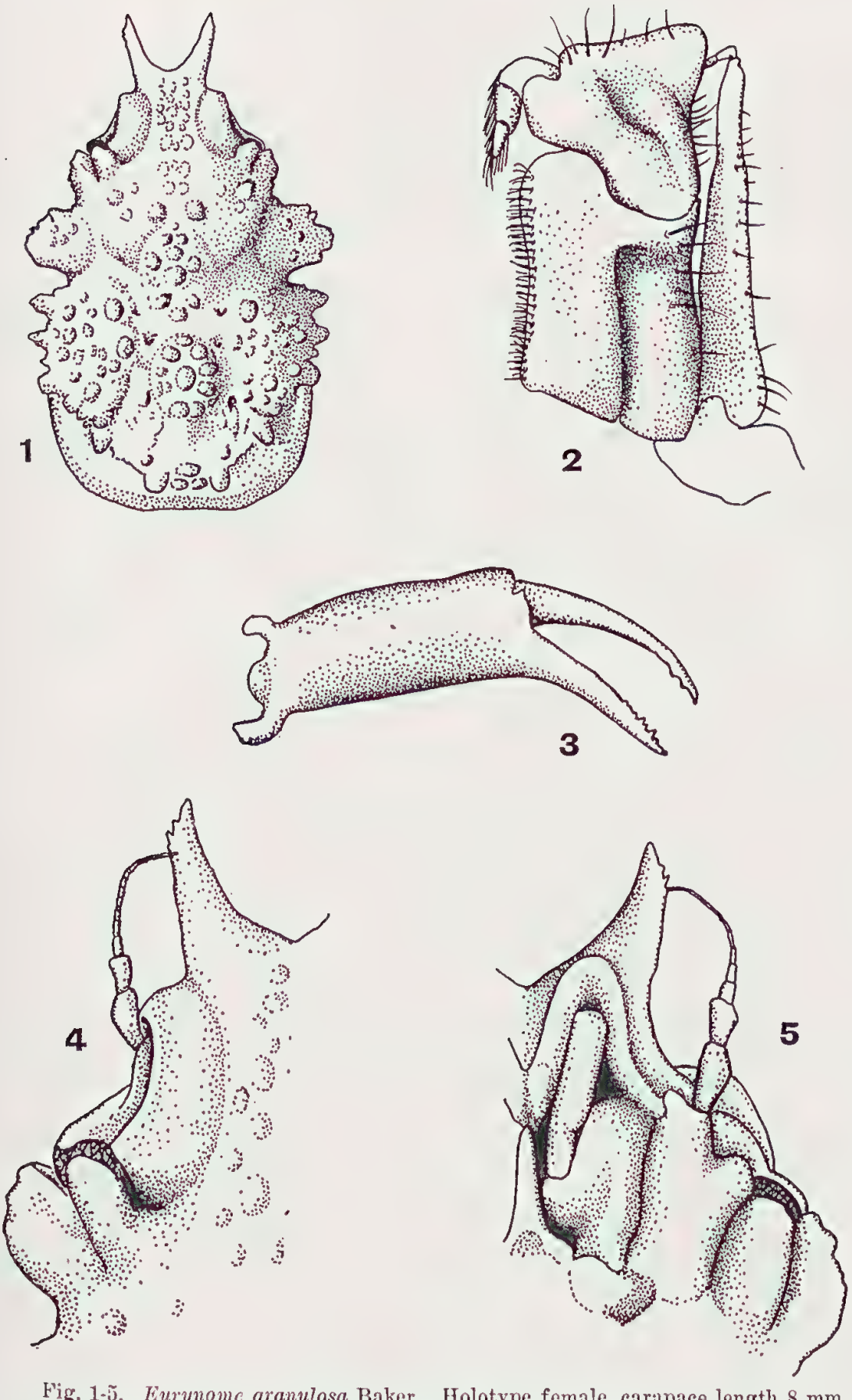


Fig. 1-5. *Eurynome granulosa* Baker. Holotype female, carapace length 8 mm. 1, carapace, dorsal view; 2, left third maxilliped; 3, outer view of right chela; 4, dorsal view of left orbit; 5, ventral view of left orbit.

Diagnosis: Carapace subpyriform to subovate, hepatic margins laterally extended; dorsal surface bearing simple tubercles arranged in groups medially only; branchial margins with several conical tubercles. Rostral spines widely separated, less than $\frac{1}{8}$ carapace length. Ambulatory legs smooth. Basal antennal article bilobate anteriorly. Intercalated supraorbital spine a broad, distally rounded lobe.

Description: The following description is based on the holotype, an adult female.

Carapace subpyriform to subovate, convex, covered by short, stiff hairs, hepatic margins greatly expanded laterally, posterolateral margins smoothly rounded; dorsal surface covered by low tubercles arranged in the midline in distinct groups, regions well demarcated by prominent smooth grooves. Rostrum of two, short, slender, subconical spines, separated from close to base by a broad, U-shaped hiatus, moderately divergent, distance between tips barely exceeding basal width, somewhat greater than margins of rostrum; lateral surface close to tips armed with three short, sharp spinules.

Hepatic margins laterally extended as very prominent, rounded, irregularly emarginate, flattened lobes bearing a few small tubercles dorsally. Branchial margins bearing anteriorly three or four subconical tubercles situated subequidistantly, first and second tubercles pointed, last tubercle blunt, at widest part of carapace, a small tubercle situated midway between second and third tubercles, a group of three or four subdorsal tubercles curving around from last marginal tubercle to posteromedial corner of branchial region.

Dorsal surface of carapace covered by large and small, oval to circular tubercles arranged in groups on the meso-, meta-, and urogastric regions and on the cardiac and intestinal regions. Protogastric regions almost smooth, bearing a few scattered tubercles, branchial regions bearing numerous irregularly arranged, crowded tubercles. Mesogastric region covered for its entire length by close set, small tubercles, increasing slightly in size posteriorly; metagastric region with six tubercles, five arranged in a transverse oval around a central one, posterior tubercles larger; urogastric region with three tubercles, slightly smaller than metagastrics, arranged in a semicircle, two anterior, submedial, one posterior, medial; cardiac region weakly tumid, bearing a group of 10 tubercles, a single medial one surrounded by nine arranged in an elongate oval; intestinal region almost smooth,

bearing close to posterior margin a group of three close-set tubercles, one anterior, medial, two posterior, submedial, the group flanked by two larger, blunt, subconical tubercles. Protogastric regions with a triangular group of three small tubercles laterally, close to base of postorbital lobe and a pair of large, submedial tubercles slightly behind and close to, posterior margin of mesogastric region.

Orbit consisting above of supraorbital eave, intercalated spine and postorbital lobe, closely approximated, separated by narrow fissures; supraorbital eave moderately wide, sharply angled antero-laterally, nowhere extended as lobes or spines, smooth; intercalated spine a prominent, broad lobe, rounded distally; postorbital lobe broad, weakly depressed, tip rounded, posterolateral margin irregularly crenulate, anterior face weakly excavated. Eyestalk stout, smooth, bulbous basally, only partly visible in either dorsal or ventral view when retracted; cornea terminal, circular. Orbit completed below by basal antennal article and a broad, distally rounded infraorbital lobe or plate separated from ventral edge of postorbital lobe only by a very narrow fissure.

Basal antennal article subrectangular, anterior edge deeply incised to become bilobate, medial lobe truncate, lateral lobe rounded, lateral and medial edges weakly concave; flagellum short, hardly extending beyond tip of rostrum, visible in both dorsal and ventral view.

Antennular fossae subovate, anterior margin a prominent ridge; interantennular spine poorly developed, blunt, weakly grooved medially; anterior process of epistome slender, sharply pointed. Epistome slightly wider than long, medial rim of opening of green gland elevated. Mouthfield subquadrate, anterior margin weakly concave, anterolateral angle elevated and weakly extended laterally. Pterygostomian regions subtriangular, densely tuberculate, separated by a very deep groove from inflated, densely tuberculate subhepatic regions.

Third maxillipeds widely gaping at midline. Ischium subrectangular, medial half of distal edge moderately extended anteriorly, rounded, lateral half weakly concave to bear merus, medial edge lacking teeth, overlain by a fringe of short hairs; outer surface deeply excavated medially as a narrow, longitudinal groove. Merus subquadrate, as wide as ischium but slightly shorter, anterolateral corner sharply angled and strongly expanded laterally as a triangular lobe, medial edge rounded, distal edge with a shallow, U-shaped notch,

outer surface with a deep longitudinal groove medially. Palp arising from notch of, and slightly longer than, merus, subcylindrical, stout, bearing a dense fringe of hairs laterally.

Chelipeds stout, hardly longer than carapace, subcylindrical except for weakly subtrigonal merus and compressed propodus, smooth, densely covered by a mat of fine, short hairs. Basis and ischium short, ischium extending along ventral surface of merus for but a short distance; merus and chela subequal, each about $\frac{1}{3}$ total length of cheliped, carpus about $\frac{1}{3}$ merus, dactyl as long as palm. Merus stout, following segments slender; carpus weakly ridged dorsally, otherwise smooth; palm of almost even height throughout, fixed finger bent at low angle from palm; fingers gaping linearly throughout their length, smooth along inner edges except distally, fixed finger with four small but nevertheless prominent conical teeth close to tip preceded by several irregular crenulations, dactyl with several irregular, low teeth, likewise close to tip.

Ambulatory legs short, first leg not greatly exceeding carapace in length, following legs decreasing regularly to last which is $\frac{2}{3}$ carapace, approximately; surfaces smooth, densely covered by short, fine hairs. Meri long, about $\frac{1}{3}$ total length of leg, carpi and propodi subequal, about $\frac{1}{2}$ meri, dactyli about $\frac{1}{2}$ propodi, terminating in a sharp, weakly falciform claw.

Abdomen seven-segmented, wide, covering all of sternum, extending laterally to base of ambulatory legs, anteriorly to posterior border of mouthfield; subovate, smooth except for a prominent medial ridge which appears on the first segment in dorsal view as a transversely oval tubercle.

Measurements: Female holotype: length 8 mm, width 5 mm, rostral length 1 mm, rostral width 1.3 mm, chelar length 2.5 mm.

Remarks: The three additional specimens differ from the holotype only in some minor features. In all, the posterolateral margin of the carapace is armed with about eight very small tubercles, there is a small tubercle on the posterolateral corner of the supraorbital eave and the hepatic margin is quadrilobate. In one specimen the first three lobes of the hepatic margin are produced into strong tubercles, the postorbital lobe is bilobate distally and the three spinules on the lateral surface of the rostrum near the tip are very blunt. Except for the arrangement of some of the tubercles on the gastric regions, the three specimens otherwise exactly resemble the holotype.

GENERAL DISCUSSION

In the original description of *Eurynome granulosa,* Baker (1906) states that the tubercles of the dorsal surface of the carapace are not crowded and only the larger tubercles are mentioned; his figure 3 gives an entirely erroneous impression, showing the tubercles to be evenly distributed over the carapace. Examination of the holotype at once shows that in the midline at least, the tubercles are arranged in distinct groups, a feature characteristic of other species of the genus. The basal antennal article is correctly described as bilobate but Baker's figure 3a shows this structure divided for at least the anterior half by a distinct groove, whereas it is merely incised anteriorly and completely lacks a groove. Further, Baker's figure 3a does not make clear the precise form of the third maxillipeds, although his description is better. Other minor errors in Baker's description are that his figure 3 shows the antennae as extending well beyond the rostral spines, whereas it reaches only to the tip, and the fissures between the eave, intercalated spine and postorbital lobe appear larger than they are actually.

Among the species at present placed in *Eurynome, E. granulosa* appears to be most closely related to the South African *E. elegans* Stebbing. Elsewhere (Griffin, 1964) these two species have been considered to form a separate group—the "*elegans* section"—characterized by having the tubercles more or less evenly distributed over the carapace. In view of the description presented here, the section would better be characterized by the possession of simple, conical tubercles as opposed to the single or fused flat-topped tubercles of other species. The two species further agree in having the merus of the third maxillipeds laterally extended but several other species of the genus also exhibit this character. *E. elegans* differs from *E. granulosa* in that there is no intercalated supraorbital spine (according to Stebbing's plate XIII), and the posterior part of the carapace is densely covered by tubercles, while in *E. granulosa* these parts are almost smooth. No comparison is possible as regards the chelipeds since these are not described for *E. elegans.* The basal antennal article of *E. elegans* is apparently quite different from that of *E. granulosa* in being subovate, the hepatic margin is extended laterally only as a small, narrow lobe and the meri of the ambulatory legs are carinate dorsally.

Comparison of the specimens before me of *E. granulosa* and the descriptions and figures of the Japanese species, *Chionognathus reini*

(Balss) given by Yokoya (1933: 158, text-fig. 57, as *Eurynome reini*) and Sakai (1938: 273, text-figs. 34a, b, plate xxvii, fig. 2) shows some remarkable similarities between the two. Both species agree in the small size, subpyriform to subovate carapace covered by groups of tubercles along the midline, prominently laterally extended hepatic margins, presence of short tubercles along the anterior part of the branchial margins, slender widely divergent rostral spines, form of the eave (Yokoya's fig. 57 does not show an intercalated spine, but Sakai describes the eave as possessing this structure) and infra-orbital margin, form of the basal antennal article and interantennular spine and of the ischium and merus of the third maxillipeds. In addition, the abdomen is seven-segmented and the chelipeds and ambulatory legs are short. *C. reini* differs from *E. granulosa* in that the anterior part of the branchial margins widen distinctly posteriorly and are not subparallel, the rostral spines bear only a single small tubercle on the lateral surface near the tips, the carpus of the chelipeds bears a single small tubercle laterally, the fingers are short and finally the ischium and merus of the third maxillipeds are fused. It is upon this last character that Rathbun (1932) based the genus *Chionognathus*. Therefore it is important to note that in *E. granulosa,* while these two segments of the maxillipeds are distinct, the junction seems a very narrow, shallow, groove and it is possible that the merus is not freely moveable. In view of these similarities it seems probable that *E. granulosa* is closely related to *C. reini,* possibly more so than to *E. elegans,* or any other species at present placed in *Eurynome.*

E. granulosa differs from the type species of the genus *E. aspera* (see Hartnoll, 1960) in that the tubercles of the carapace are simple and conical, not flat-topped, the basal antennal article is not truncate anteriorly, the intercalated supraorbital spine is large, not minute, and in several other minor characters. With the important reservation that comparison of the pleopods is not possible, I do not think that any of these differences warrant the exclusion of *E. granulosa* from the genus *Eurynome.*

LITERATURE CITED

Baker, W. H., 1906: Notes on South Australian Crustacea. Pt. 4. Trans. Roy. Soc. S. Aust. 30: 104-117, pls. I-III.

Barnard, K. H., 1950: Descriptive Catalogue of the South African Decapod Crustacea (Crabs and Shrimps). Ann. S. Afr. Mus. 38: 837 pp., 154 figs.

Garth, J. S., 1958: Brachyura of the Pacific Coast of America: Oxyrhyncha. Allan Hancock Pacif. Exped. 21: xii + 854 pp., 106 tables, 9 text-figs., 85 pls.

Griffin, D. J. G., 1964: A Review of the genus *Eurynome* Leach (Decapoda, Majidae) and a new species from New Zealand. Crustaceana 6(3): 195-206, figs. 1-11.

Hale, H. M., 1927: The Crustaceans of South Australia. Pt. 1. Adelaide: Govt. Printer. 201 pp., 202 figs.

Hartnoll, R. G., 1960: A critical re-examination of the spider crab *Eurynome* Leach from British waters. Crustaceana 2(3): 171-182, figs. 1-7.

Rathbun, M. J., 1925: The Spider Crabs of America. Bull. U.S. Nat. Mus. 129: xx + 613 pp., 153 text-figs., 283 pls.

——— 1932: Preliminary descriptions of new species of Japanese crabs. Proc. biol. Soc. Washington 45: 29-38.

Sakai, T., 1938: Studies on the Crabs of Japan. III. Brachygnatha, Oxyrhyncha. Tokyo: Yokendo Co. Pp. 193-364, 55 figs., 41 pls.

——— 1961: New Species of Japanese Crabs from the Collections of His Majesty the Emperor of Japan. Crustaceana 3(2): 131-150, text-figs. 1-4, pls. III, IV.

Stebbing, T. R. R., 1921: South African Crustacea. (Part XI of South African Crustacea for Marine Investigations of South Africa.) Ann. S. Afr. Mus. 18 (4): 453-468, pls. XIII-XX.

Yokoya, Y., 1933: On the Distribution of Decapod Crustaceans inhabiting the Continental Shelf around Japan, chiefly based upon the Materials collected by S. S. Sôyô-Maru, during the Year 1923-1930. J. Coll. Agric. Tokyo Imper. Univ. 12(1): 1-226, text-figs. 1-71.

RESUME

On rédécrit et figure de quatre examplaires, comprenant l'holotype, le crabe majid, *Eurynome granulosa,* ne connu que l'Australie du Sud, et on traite de sa position systematique. On donne emphase des similarités nombreuses avec *Chionognathus reini,* un espèce du Japon. Entre les espèces comprises aux confins d'*Eurynome, E. granulosa* se rapproche le plus de l'*E. elegans* de l'Afrique du Sud.

A REVISION OF THE AUSTRALIAN AND NEW GUINEA DRYMINI (HETEROPTERA-LYGAEIDAE)

By GORDON F. GROSS, Senior Curator of Invertebrates,
South Australian Museum

Plates 3-7, text fig. 1

SUMMARY

Two species of Australia and one of New Guinea Drymini were previously known. As a result of this study, using all available Australian collections, two species are shown to occur in New Guinea, one a common Australian species, and seventeen species, fifteen of them new, are recorded from Australia. All eighteen species are keyed, figured, and described, and have been placed in twelve genera, eight of which are new. Where available male genital capsule dorsal morphology was used along with external details to provide a clue to the arrangement and relationships of these twelve genera.

INTRODUCTION

The Drymini are a tribe of the complex subfamily Rhyparochrominae of the family Lygaeidae. Rhyparochrominae may be easily distinguished from other subfamilies of Lygaeidae by having the fourth abdominal intersegmental suture (usually the second visible, I and II are usually hidden by the metathorax) not reaching the outer (or upper) edge of the abdomen ventrally, but instead it curves away forward and becomes evanescent before reaching the apical end of the second suture (text fig. A). The Drymini have the spiracle on segment IV of the abdomen ventral in position and have two dull spots each bearing a long hair (trichobothrium) on sternum V above the curved portion of the fourth abdominal suture, the hindmost of these is placed *in front* of spiracle V (text fig. A).

Three species were known from Australia and New Guinea; *Mizaldus woodwardi* from New Guinea, and *Paradrymus exilirostris* and *Taphropeltus australis* from Southern Australia.

Through the good offices of the Directors of the Australian Museum, Sydney, the National Museum, Melbourne, the Chief C.S.I.R.O., Division of Entomology, Canberra, Dr. T. W. Woodward, Department of Entomology, University of Queensland, Brisbane, and Mr. Cremer, Tasmanian Forestry Commission, Maydena, Tasmania, I was able to assemble almost, if not all, available specimens of Australian and New Guinea Drymini in Australian collections. Since this paper was submitted and during proof reading I have received notification of an impending loan of a collection of New Guinea Drymini from the Bishop Museum, Honolulu. This material will be treated in a subsequent paper.

Taphropeltus australis can no longer be placed in the Northern Hemisphere genus *Taphropeltus* and for this species a new genus had to be created. I was able to recognize 18 species of this tribe from Australia and New Guinea, two from New Guinea and seventeen from Australia (one species is shared). Fifteen of these species are new. The species have been arranged in twelve genera, seven of these are new, and apparently restricted to Australia (6) or Australia and New Guinea (1). Of the five previously described genera *Paradrymus* is exclusively Australian, *Brentiscerus* occurs outside Australia only in New Zealand, *Appolonius* occurs also in India, Sarawak and the New Hebrides (Scudder *in litt.*) and Africa, *Mizaldus* in Africa and India, and *Scolopostethus* is rather widely distributed.

In arranging the genera satisfactorily a number of difficulties were encountered using such features as presence or absence of lateral explanate keels to the pronotum, whether the pronotum was transversely constricted, and whether the scutellum had a prominent triradiate keel or not. To help resolve these problems male genitalia where available were extracted and studied after potashing the tip of the abdomen. A discussion on these points follows the systematic descriptions.

In the lists of disposition of specimens the following abbreviations have been used.

A.M. . . . . Australian Museum, Sydney.
A.N.I.C. . . . . Australian Insect Collection, Canberra.
N.M. . . . . National Museum, Melbourne.
Q.M. . . . . Queensland Museum, Brisbane.
S.A.M. . . . . South Australian Museum, Adelaide.
U.Q. . . . . Department of Entomology, University of Queensland, Brisbane.

I wish to express my appreciation to the Directors of these museums, the chief of the C.S.I.R.O. Division of Entomology, Dr. T. E. Woodward, University of Queensland, and Mr. Cremer, Maydena, Tasmania for the opportunity to see their material.

KEY TO AUSTRALIAN AND NEW GUINEA GENERA OF DRYMINI

1.	5 mm long or longer	2.
	Under 4.5 mm long	3.
2.	First antennal segment just surpassing apex of head; head apically very acuminate; pronotum markedly sinuate in region of transverse constriction. Apex of fore tibiae of male with a strong spine	*Paradrymus* Bergroth
	First antennal segment markedly surpassing apex of head which is not markedly acuminate; pronotum only vaguely sinuate laterally in the region of the transverse constriction	*Megadrymus* gen. nov.
3.	Lateral margins of pronotum carinate or marginate but not explanate, *i.e.*, not forming a narrow flange along the lateral margins	*Mizaldus* Distant
	Lateral margins of pronotum carinate and explanate along most of their length	4.
4.	Lateral margins of pronotum straight and/or convex but not or only very slightly concave in region of transverse impression	5.
	Lateral margins of pronotum strongly concave in region of transverse constriction	10.
5.	Transverse constriction of pronotum virtually absent	*Brachydrymus* gen. nov.
	Transverse constriction present	6.

6. Transverse constriction placed well behind middle . . . . . 7.
   Transverse constriction placed about middle . . . . . 8.
7. Sides of pronotum in basal $\frac{2}{3}$ virtually parallel . . . . . *Retrodrymus* gen. nov.
   Sides of pronotum convex from humeral angles to region of collar *Austrodrymus* gen. nov.
8. Sides of pronotum convex or if straight strongly converging anteriad, pronotum much wider at base than apex (2:1) . . . . . 9.
   Sides of pronotum straight almost parallel from base to apex, pronotum very little wider at base than apex (9:7) . . . . . *Apollonius* Distant
9. Hemelytra conspicuously wide in region of apical $\frac{2}{3}$ of corium . . . . *Gastrodomorpha* gen. nov.
   Hemelytra with corial margin more parallel, conspicuously convex at about $\frac{1}{3}$ of exterior corial margin . . *Isopeltus* gen. nov.
10. Transverse constriction placed well behind middle . . . . . *Pseudodrymus* gen. nov.
    Transverse constriction placed about middle . . . . . 11.
11. Scutellum with a prominent triradiate keel . . . . . *Brenticerus* Scudder
    Scutellum without a prominent triradiate keel . . . . . *Scolopostethus* Fieber

Mizaldus Distant 1901

Mizaldus Distant, 1901, Ann. Mag. nat. Hist., (7)8: 483. 1903, Fauna Brit. Ind. Rhynch., 2: 68. Bergroth, 1918, Philipp. J. Sci., 13(2 & 3): 87.

Head triangular, pointed in front of eyes. Eyes not quite touching anterior margin of pronotum. Ocelli close to eyes and remote from anterior margin of pronotum, widely separated. First segment of antennae somewhat incrassate and extending well in front of head,

second segment the longest. Pronotum with anterior margin narrower than head with eyes, fore lobe semiglobose, a strong medial transverse constriction separating fore and hind lobe, the latter flatter than fore lobe; outer margins of fore lobe strongly convex to region of transverse constriction, margins of hind lobe likewise very convex, hind margin feebly sinuate, humeral angles slightly raised. Only a feeble keel along lateral margins of pronotum.

Scutellum acute apically, medially elevated into a triangular tumescence, not into a triradiate keel as many other Australian Drymines, in front of tumescence depressed.

Corium somewhat longer than abdomen, outer margin of corium shallowly concave and pilose in basal half.

Fore femora moderately incrassate, unarmed, or with upwards of nine spines on the distal half of the ventral surface, the first spine large.

Type: *Rhyparochromus dimidiatus* Walker, 1872 = *Mizaldus woodwardi* Slater & Carayon 1963, selected by Distant 1903, *loc. cit.*: 68.

Mizaldus woodwardi Slater & Carayon, 1952

Plate 4, fig. A

Rhyparochromus dimidiatus Walker, 1872, Cat. Heter., 5: 107 (preocc.).

Mizaldus dimidiatus Distant, 1901, Ann. Mag. nat. Hist., (7)8: 484.

Mizaldus woodwardi Slater and Carayon, 1963, Proc. R. ent. Soc. Lond., (A)38: 4.

Head, anterior lobe of pronotum, depressed parts of scutellum, and thorax beneath piceous black. Anteclypeus, hind lobe of pronotum, median raised portion of scutellum, most of distal portion of corium and patches on membrane, first segment of antennae, hind margin of metathorax, femora, and whole abdomen brown, the latter with fine golden pilosity. Terminal three segments of antennae, tibiae and tarsi, basal third of corium and a marginal spot near apex, and patches on membrane luteous, veins white.

Eyes large and prominent but not pedunculate, head with a few scattered punctations, quite difficult to see, otherwise smooth with a scattered pilosity. Antennae pilose, hairs about as long as diameter of second segment, ratio of segments 32: 56: 37: 37.

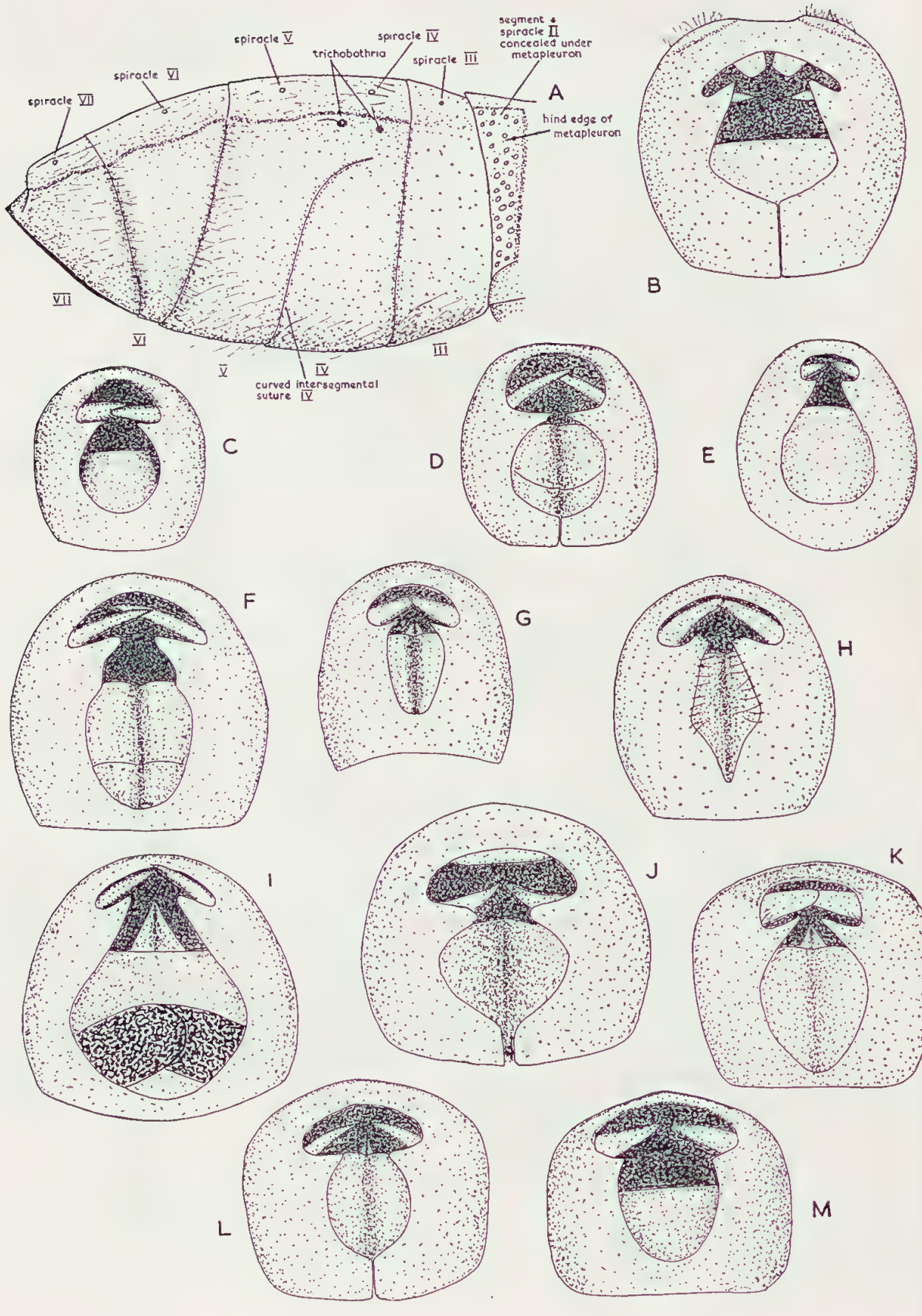

spiracle V
spiracle IV
trichobothria
spiracle III
segment 4
spiracle II
concealed under
metapleuron
spiracle VI
spiracle VII
A
hind edge of
metapleuron
VII
VI
V
IV
III
curved intersegmental
suture IV
B
C
D
E
F
G
H
I
J
K
L
M

Fig. 1

A. Side view of abdomen of Drymine (*Retrodrymus abundans* n.sp.) showing arrangement of trichobothria on Segment IV and the typical Rhyparochromine curved fourth intesegmental suture.

B. Male genital capsule from above of *Megadrymus terraereginae* n.sp.

C. Male genital capsule from above of *Isopeltus australis* (Bergroth).

D. Male genital capsule from above of *Paradrymus exilirostris* Bergroth.

E. Male genital capsule from above of *Brentiscerus pallidus* n.sp.

F. Male genital capsule from above of *Brentiscerus major* n.sp.

G. Male genital capsule from above of *Brentiscerus triocellatus* n.sp.

H. Male genital capsule from above of *Retrodrymus abundans* n.sp.

I. Male genital capsule from above of *Appolonius territorialis* n.sp.

J. Male genital capsule from above of *Scolopostethus forticornis* n.sp.

K. Male genital capsule from above of *Pseudodrymus florestalis* n.sp.

L. Male genital capsule from above of *Austrodrymus flindersi* n.sp.

M. Male genital capsule from above of *Brachydrymus lateabundans* n.sp.

Pronotum wider than long (100:62), fore lobe almost glabrous, smooth except for a few scattered small punctations; hind lobe pilose near lateral margins with denser and large punctations.

Scutellum sparsely punctate, almost glabrous. Hemelytra almost glabrous but sparse hairs on clavus and basal half of corial margin. Clavus with three parallel rows of punctations. Corium with two rows parallel to and immediately adjacent to claval suture and a half row paralleling outer basal margin of corium, basal third of remaining corium almost free of punctations, apical $\frac{2}{3}$ with scattered heavy punctations.

Beneath with sparse scattered punctations on thoracic pleura, abdomen impunctate. Fore femora thickest, with on distal half beneath about 9 spines in irregular row on inner edge, fourth very large, and several spines on outer edge.

Length: 4.25 mm.

Type: New Guinea, in British Museum (Nat. Hist.). Our specimen, a female from Mount Lamington, N.E. Papua, 1,300-1,500 feet, C. T. McNamara (S.A.M.).

Mizaldus lacks the prominent explanate margin of other Australian Drymines and cannot be easily linked with any other genus.

Megadrymus gen. nov.

Large for the tribe, subelongate, hemelytra tapering somewhat posteriad. Head relative small, relatively elongate, width: length about 20:15, but not exceptionally produced in front of eyes, tylus normally formed. Eyes nearly touching anterior margin of pronotum, ocelli remote from each other and in a line formed by hind margins of eyes. First segment of antennae slender, surpassing apex of head by about $\frac{2}{3}$ of its length. Remaining segments longer, second the longest.

Anterior margin of pronotum obviously concave, lateral margins strongly convex in anterior third thence almost straight and diverging to humeral angles, perhaps very slightly indented in region of transverse constriction. Fore lobe of pronotum moderately convex, declivous towards collum giving pronotum an arched appearance in side view, transverse constriction between fore and hind lobes placed slightly behind middle, hind lobe hardly convex.

Scutellum large with a prominent triradiate keel, the basal arms of this keel enlarged and swollen, apical arm reaching apex of scutellum. Lateral margins of corium feebly excavate at region of apical half of scutellum. Two rows of punctations on corium paralleling claval suture separated from each other by a raised callous area, a line of punctures more or less paralleling outer edge in basal outer half of corium, breaking up into scattered punctations in distal half. The veins apparent on corium, the callous area near claval suture, the space between the outer line of punctations bordering this vein and the median vein impunctate, space between median and outer vein with scattered punctations. Clavus with three rows of punctations, the median converging steadily towards the outer posteriad and coalescing with it before apex.

Whole thorax beneath strongly punctate except evaporative areas and two shagreened areas on lateral margins of meso- and metapleura. Underside of head parallel to vertex to level of anterior margins of eyes, thence suddenly convex to apical margin of prothorax. Abdomen finely pilose and impunctate. Fore femora incrassate and heavily armed with denticles on both ventral margins in apical half, one a large spine.

Male genital capsule with upper opening partially divided into two by inwardly directed processes of the lateral margins, claspers shaped rather like scorpion venom glands, proctiger covering whole of anterior cavity.

Type: *Megadrymus terraereginae* sp. nov., the only species in the genus.

Megadrymus terraereginae sp. nov.

Plate 3, fig. D. Text fig. 1B

Fuscous black; antennae, lateral explanate margin of pronotum, and in one specimen hind lobe of pronotum, scutellum, and hemelytra testaceous above. Beneath in all examples (except rostrum and legs which are testaceous and in one example the hind margins of the pro and metapleura) fuscous. Apical $\frac{2}{3}$ of last antennal segment and some apical spots on the corium pale testaceous or luteous, membrane a very pale smoky, veins and immediate areas on either side whitish.

Ratio of segments of antennae 12:20:19:18. Head very much shorter than pronotum, 10:32. Fore femora with apical halves flattened, beneath with smaller spines and a large spine on the anterior margin.

Length: 5.8-6.0 mm.

Localities: Queensland holotype (female) [Reg. no. T6212], Brisbane, 15 November 1962, coll. E. B. Teh (Q.M.); allotype (male), Eagle Heights Mount Tambourine, from leaf mould in rain forest, 18 July 1954, coll. T. E. Woodward; paratype (female), Toowoomba, 2 February 1951, coll. J. Letchford (U.Q.).

Paradrymus Bergroth 1916

Paradrymus Bergroth, 1916, Proc. roy. Soc. Vict. 29: 11.

Body ovate, head elongate, anteclypeus (tylus) strongly produced. Eyes prominent, remote from anterior margin of pronotum, ocelli in a line formed by rear margins of eyes, widely separated. Antennophores prominent, first segment of antennae not incrassated, about as thick as the terminal segments, second segment the longest.

Anterior margin of pronotum almost straight, perhaps a little concave, with a prominent collar. Lateral margins of pronotum marginate and explanate, humeral angles somewhat produced, otherwise hind margin straight or feebly concave. Fore lobe of pronotum convex, separated from hind lobe by a transverse constriction; hind lobe flatter, foveate anteriorly in the middle and feebly laterally just inside the raised humeral angles. Lateral margins of fore lobe convex to transverse impression, of hind almost straight.

Scutellum acuminate with a prominent central triradiate carina, the tip of the central arm almost reaching apex. Lateral margins of scutellum feebly sinuate when clavus lifted, lateral margins of corium sinuate, noticeably concave in region of about half length of scutellum. Clavus with three not very parallel rows of punctures, corium with three rows adjacent to claval suture and otherwise fairly densely punctate, with two or three prominent longitudinal raised veins. Whole thorax beneath strongly punctate with the exception of the evaporative area. Fore femora incrassated and armed with a series of small tubercles and one large one distally. Abdomen impunctate and covered with dense fine pilosity.

First segment of tarsi longer than the other two together, first segment of hind tarsi very long. Apex of fore tibia of male with a strong prominent outwardly directed spine. Male genital capsule with dorsally directed opening divided into two by the outer margin giving off two acute and inwardly directed lobes (which however hardly rate as parandria). Most of front aperture covered by proctiger which is

prominently grooved longitudinally in the middle and cylindrically convex on either side of this. Hind aperture with two needle shaped claspers (parameres).

Type: *Paradrymus exilirostris* Bergroth 1916, monobasic.

Only one species in the genus, the type.

Paradrymus exilirostris Bergroth 1916

Plate 3, figs. A, B, C. Text fig. 1D

Paradrymus exilirostris Bergroth, 1916, Proc. roy. Soc. Vict., 29: 12.

Black, finely and subgranulately punctate, posterior lobe of pronotum and corium usually testaceous, punctate with fuscous, some lateral and discal spots on corium paler. Laminate margin of pronotum pale testaceous, also apical $\frac{2}{3}$ to $\frac{1}{2}$ of last segment of antennae. Membrane luteous, variegate with fuscous.

Beneath with femora black, tibiae and tarsi castaneous. Fore femora moderately incrassate, armed distally with six small and one large spine on ventral anterior margin, underside of fore femora flattened in apical half.

Length: 4.5-5.6 mm.

Localities: Bergroth records the species from Queensland and Victoria. I have seen specimens from South Australia: Croydon (S.A.M.); New South Wales: Mt. Kosciusko, 24 Nov. 1921, coll. R. J. Tillyard (A.N.I.C.); Hacking River National Park, August 1952, by sweeping bushes in forest, coll. J. Armstrong (U.Q.); Mt. Kosciusko, 5,000 feet, March 1889, coll. Helms; Mt. Kosciusko, Jan. 1937, coll. H. J. Carter; Island Bend, Mt. Kosciusko, 4,100 feet, 27 November 1952, coll. J. Armstrong (A.M.); Victoria: Halls Gap, 20 October 1945, coll. A. Burns (N.M.). Queensland: Brisbane, 6 Feb. 1946, coll. Brimblecombe; Lamington National Park, 29 Oct. 1957, from leaf mould, coll. I. C. Yeo; Bulburin State Forest, 27-29 May 1960, coll. E. A. Bernays (U.Q.); Emerald District, Aug. 1904, coll. E. J. (N.M.).

Isopeltus gen. nov.

Moderate in size within the tribe Drymini. Head large in relation to the size of the pronotum, strongly rugulose, anteclypeus (tylus) prominent but not unduly produced. Eyes prominent, ocelli remote from each other and in a line with the hind margins of the eyes.

Antennae long, longer than the head and pronotum together, first segment considerably surpassing apex of head, second and third segments almost equal in the type species, second segment considerably the longest in the other two, antennae robust in two of the three species. Rostrum normal, the second segment the longest.

Pronotum with distinct collar, anterior and posterior margins almost straight, lateral explanate margin of pronotum straight and converging anteriad in basal $\frac{1}{2}$ to $\frac{2}{3}$ thence convex to become obsolete at base of collar, these lateral explanate margins relatively wide. Pronotum with a strong transverse impression in the middle, fore lobe strongly convex, hind lobe much less so, collar and hind lobe strongly punctate, fore lobe finely punctate.

Scutellum punctate, moderate in size with a prominent triradiate keel, the apical arm of which reaches the apex of the scutellum. Lateral margins of corium moderately sinuate, two rows of punctations paralleling claval suture and a basal outer half row more or less parallel to outer margin, remainder of corium with scattered punctations. Clavus with three rows of rather fine punctations, the median one converging towards the outer row posteriad and coalescing with it before apex.

Underside of head rugulose like upper side, thorax beneath punctate, prothorax heavily punctate, meso- and metathorax more finely so. Abdomen covered with a fine pilosity. Fore femora incrassate and armed on anterior margin of flattened apical ventral surface only. One spine large. Only the male genital capsule of the type species is available for study. The upper opening is partially divided into two by acute inward projections of the outer rim, two blunt parameres are present in the rear cavity while the proctiger does not cover the whole of the anterior cavity.

Type: *Taphropeltus australis* Bergroth 1916.

The affinities of this genus are undoubtedly with *Brentiscerus* Scudder from which it differs in lacking a concave hind or lateral margin to the pronotum and the external margin of the corium is only feebly concave basally. There are three species in the genus, two of them new; they may be separated by the following key:—

1. Antennae robust . . . . . 2.

   Antennae slender . . . . . *Isopeltus tenuicornis* sp. nov.

2. Hemelytra mainly black, in apical half with about 4 pale patches . . . . . *Isopeltus obscurus* sp. nov.

Hemelytra mainly pale with apex and median transverse bar across corium fuscous . . . . . *Isopeltus australis* (Bergroth).

Isopeltus australis (Bergroth 1916) nov. comb.

Plate 4, fig. B. Text fig. 1C

Taphropeltus australis Bergroth, 1916, Proc. roy. Soc. Vict., (N.S.) 29(1): 13.

Head black and finely and very thickly punctate, as long or longer than anterior pronotal lobe; antennae rather robust in comparison to the other species in the genus, piceous or testaceous, apical segment sometimes lighter. Rostrum testaceous, reaching middle of mesosternum. Pronotum distinctly impressed just behind middle, anterior lobe black, finely and very thickly punctate, longer than the stramineous hind lobe, the latter finely punctate and with five fuscous vittae of varying disposition, sometimes almost parallel. Sides of pronotum laminate, *not* sinuate in region of pronotal constriction, pale.

Scutellum black, finely punctate, with a median triradiate keel, apex and lateral vittae between the median and lateral arms of the keel paler. Corium and clavus stramineous, the former with a median transverse bar and apex infuscated, also the three longitudinal veins. Clavus with three rows of punctations, corium with two rows parallel to the claval suture and other fine scattered punctations. Membrane pale and fuscous variegate, veins pale.

Underside mostly black, episterna, epimera, hind margin of metapleuron and legs brown to stramineous.

Fore femora incrassate and armed with one large central spine beneath and a series of smaller spines both interior and exterior to this.

Length: 2.5-4.5 mm.

Originally described from Victoria but quite widely distributed. South Australia: Whyalla, 10 August 1947, coll. D. S. (N.M.); Underdale, 30 December 1960, coll. G. F. Gross; 2, Mt. Lofty Ranges, 1 in tussocks, coll. N. B. Tindale; Second Creek, Mt. Lofty Ranges, 7 November 1884, coll. J. G. O. Tepper; 2, Adelaide, 1 in flood debris, coll. A. M. Lea; Lucindale, coll. Feuerheerdt; Mern Merna, at light,

2 November 1959, coll. P. Aitken (S.A.M.). Tasmania: Hobart, coll. A. M. Lea (N.M.) 1 ditto; Hobart, 11 August 1915, coll. C. Cole; Cradle Mountain, coll. Carter and Lea; 2, Launceston; St. Marys; 3 Strahan, 1 in moss and lichens, coll. Lea and Carter (S.A.M.); 2 Maydena, in presence of fruits of *Eucalyptus regnans*, 20 November 1962, coll. K. Cremer (Tas. Forestry Commission); Mt. Wellington, Hobart, 26-29 January 1955, coll. T. E. Woodward (U.Q.). New South Wales: Eccleston, in flood debris, coll. J. Hopson; 2, Dorrigo, coll. W. Herson (S.A.M.); Mt. Wilson, Blue Mountains, 8 June 1962, coll. D. K. McAlpine (A.M.); 2, Minna Murra, February 1962, coll. T. E. Woodward (U.Q.). Queensland: 3, Mt. Tambourine, coll. A. M. Lea; Blackall Ranges, coll. A. M. Lea; Rockhampton, attracted to light (S.A.M.); 3, Brisbane, at light, 16 November 1955, 7 December 1956, 25 January 1956, coll. T. E. Woodward; Mogill, Brisbane, 30 June 1956, coll. T. E. Woodward, Sunnybank, Brisbane, in light shade, January-December 1956, coll. F. S. Colliver; 2, Binna Burra, Lamington National Park, S.E. Queensland, in leaf debris amongst grass and *Eucalyptus* spp., 28 August 1953, coll. T. E. Woodward; 3, Noosa district, in sand dunes under herbs and fallen leaves and seeds of *Casuarina*, 17 April 1960, coll. T. E. Woodward; 2, Mt. Glorious, 1 on cunjeroi lilu, 1 from leaf mould, 23 September 1963, coll. G. Monteith; 1, Imbil State Forest from *Helichrysum diosmifolium* Less., 5 November 1957, coll. T. E. Woodward (U.Q.). Western Australia: Fremantle, 4 November 1934, coll. K. R. Norris (A.N.I.C.); King Georges Sound (A.M.). Norfolk Island: 8, coll. A. M. Lea (S.A.M.). Papua: Mt. Lamington, 1,300-1,500 feet, coll. C. T. McNamara (S.A.M.).

Remarks: Circumstances indicate that this little Lygaeid may be an important consumer of seed in the forest and is under investigation by the Tasmanian Forestry Commission as a possible cause of poor germination of broadcast *Eucalyptus regnans* seed.

Isopeltus obscurus sp. nov.

Plate 4, fig. D

Head black and finely and very thickly punctate, as long or longer than anterior pronotal lobe; antennae robust but more elongate than *I. australis*, second segment much the longest, densely pilose, this pilosity quite short; first three segments and base of fourth brown, apical three quarters of fourth luteous. First segment of rostrum brown, remainder yellowish, first segment subequal to second, third shorter, fourth shortest of all, black at apex.

Pronotum distinctly impressed just behind middle, anterior lobe black, finely and sparsely punctate, with a feeble longitudinal impression posteriorly. Hind lobe testaceous brown but with 2 semilunate testaceous patches on either side of the middle, anteriorly touching the transverse suture, posteriorly the open ends often not reaching the hind margin; lateral expanded margins pale, almost straight and converging in basal $\frac{2}{3}$, thence convex to region of hind margin of collar where they disappear. Hind margin almost straight, perhaps a fraction convex, anterior margin straight, perhaps a fraction concave, a distinct collar present.

Scutellum black, coarsely and sparsely punctate, with a median triradiate keel, median arm of the keel reaching the apex. Apex and two small marginal semilunate spots which touch neither the end of the median arm or the ends of the lateral arms of the triradiate keel paler, tending luteous. Sometimes two pale spots on and near the extremities of the lateral arms of the triradiate keel.

Corium and clavus substantially fuscous, sometimes the clavus almost wholly stramineous, only the median and outer rows of punctations fuscous. Corium basally stramineous, apically dark except for a luteous spot near the inner apical angle and two or three longitudinal bars exterior to this, the outer touching the exterior margin. Scattered punctations over the corium. Membrane smoky, veins white.

Underside mostly very black, brown in the Cairns specimen, episterna, epimera, hind margins of pro- and metapleura, and legs (except trochanters) brown. Underside of thorax sparsely and strongly punctate, underside of abdomen pilose.

Fore femora incrassate and armed with one large central spine beneath and a series of smaller ones exterior to it, and perhaps one interior to this. Male not available for genitalia study.

Length: 3.5-4.5 mm.

Localities: Queensland: Holotype female [Reg. no. T6215], Moggill, from leaf litter, 1 September 1963, coll. G. Monteith (Q.M.); 2 paratype females, Noosa, on sea shore, 2 September 1959, coll. I. C. Yeo; 1 paratype female, Upper Cedar Creek via Samford, 3 January 1963, coll. T. Brooks (U.Q.); 1 paratype female [Reg. no. I20,154], Cairns district, attracted to light, coll. A. M. Lea (S.A.M.). Lord Howe Island: a series of 6 nymphs mounted on a card in the S.A.M. very likely belong to this species.

Isopeltus tenuicornis sp. nov.

Plate 5, fig. B

Head black and finely punctate, about the same length as anterior pronotal lobe; first segment of antennae thicker than remaining segments, surpassing apex of head by about twice its length; second and fourth segments subequal, third somewhat shorter (45:55). First and second antennal segments and a median band on the fourth yellowish, third segment brownish-yellow. Rostrum stramineous, just reaching mid-coxae. Ratio of segments 37:45:12:15.

Pronotum strongly impressed just about the middle, anterior lobe piceous, coarsely and densely punctate, hind lobe testaceous, coarsely punctate with brown. Anterior margin of pronotum somewhat concave, hind margin straight, strongly impressed inwardly of each humeral angle. Lateral explanate margins narrow in comparison to *I. australis* and *I. obscurus,* converging anteriad, very feebly sinuate in the region of the transverse impression and convex in the anterior third, pale.

Scutellum with the usual triradiate keel, the lateral arms of which are expanded and bulbous; coarsely punctate in the apical $\frac{2}{3}$, fuscous, but the keels and the apex lighter.

Corium and clavus testaceous, with a fuscous mark near the apical third of the claval suture and another on the apical exterior margin. Strongly and coarsely punctate, the clavus with three rows of coarse punctations. Membrane pale brown hyaline.

Underside brown, femora tibiae and tarsi yellowish. Fore femora incrassate, armed with one large spine beneath, five minute spines interior to this and another five exterior to it. No males available for study of genital capsule.

Length: 3.6 mm.

Location: Holotype female [Reg. no. T6216], Brisbane, 8 December 1951, coll. G. Saunders (Q.M.).

This species differs from the other two in its genus by its much thinner antennae and narrower lateral explanate margin of the pronotum.

Brentiscerus Scudder 1962

Brentiscerus Scudder, 1962, Canad. ent., 94(9): 989.

Head distinctly punctate, first segment of antennae surpassing apex of head.

Pronotum with anterior collar; lateral margins with pale explanate margin, somewhat concave in region of transverse constriction which is placed almost in the middle of the pronotum. Hind margin sinuate, straight or slightly concave, anterior lobe more finely punctate than posterior.

Scutellum deeply punctate with a prominent Y shaped keel.

Hemelytra somewhat concave in basal third, clavus with three rows of punctations, corium with two rows close to and parallel to claval suture.

Fore femora incrassate with a large spine and apically to it a series of smaller spines.

Male genital capsule with upper opening partially divided into two by inwardly directed processes of outer rim, claspers robust, pointed, proctiger covering most of anterior opening.

Type: *Scolopostethus putoni* White 1878, from New Zealand, by original designation.

This genus, *Isopeltus, Retrodrymus* and *Gastrodes* seem to form a group within the Drymini. *Brentiscerus* differs from the other three in having the lateral explanate margins of the pronotum distinctly concave in the region of the transverse impression of the pronotum.

Brentiscerus putoni appears to have markings rather like *Isopeltus australis* and quite different from the four Australian species (all new) of the genus. These may be separated by the following key.

1. Small, under 2 mm long, pale yellow and brown in colour . . . . . *Brentiscerus pallidus* sp. nov.

   Larger, over 2 mm longer, darker, testaceous and dark brown . . . . . 2.

2. Large, 3.5 mm or over, fore femora anteriorly armed with a prominent spine just exterior to half way and prominent, though much smaller denticles exterior to this, posteriorly with 12-13 smaller denticles . . . . . *Brentiscerus major* sp. nov.

Smaller (2-3.2 mm), fore femora not so conspicuously armed, but with one minute tooth at about ¾ the distance from base beneath .. .. 3.

3. Apical half of corium dark, with three prominent parallel elongate oval pale streaks included in this dark area .. .. *Brentiscerus triocellatus* sp. nov.

Corium and clavus dark brown, with a distinct pale spot at half the length of the outer margin of the corium, and two spots near the apical margin .. .. *Brentiscerus diffusus* sp. nov.

Brentiscerus major sp. nov.

Plate 4, fig. C. Text fig. 1F

Head triangular, coarsely and densely punctate, with a long hair just interior of each eye, dark brown, eyes separated from anterior angles of pronotum, tylus prominent, paler brown. First and second segments of antennae lighter brown, third and base of fourth often dark brown, apical ½ to ⅔ of fourth very pale brown. Rostrum reaching mid-coxae, first segment just surpassing base of head, second segment reaching to middle of fore coxae, yellowish, first segment a fraction darker.

Fore lobe of pronotum brown or blackish brown, distinctly and sparsely punctate, and with just the faintest trace of a longitudinal groove. Hind lobe luteous with scattered brown punctations, and a faint longitudinal impression anteriorly joining the faint one on the fore lobe; sometimes a faint tinge of brown on the disc on either side of the midline touching the hind margin. Pronotum with a prominent transverse constriction about the middle, anterior margin somewhat concave, hind margin markedly sinuate, lateral margin concave in region of transverse constriction, and just anterior to this evenly convex to the collar. Humeral angles slightly raised interiorly and hind margins impressed on either side just behind these.

Scutellum triangular with usual triradiate raised keel. Brown, parts of the keel sometimes lighter in colour.

Clavus and corium brownish-yellow, the latter with some areas as indicated on figure slightly darker. Clavus with the usual three rows of punctations, corium with two rows close to and parallel to claval suture, and exterior to these one complete sinuate row, and several incomplete rows, as well as scattered punctations. Membrane brownish and clear hyaline, mottled.

Beneath brown, tip of genital segment, hind margins of pro- and meta-pleura, femora (except base of fore femora), tibiae and tarsi yellowish. Underside of thorax coarsely punctate, underside of abdomen with golden pilosity. Underside of fore femora with 1 large and exterior to it 6-7 small denticles on the anterior margin and about 12 small denticles along the hind margin.

Male genital capsule with upper opening partially divided into two by inwardly directed processes of the outer surface. Claspers fairly long and cylindrical, pygophore large, covering most of hind opening, grooved longitudinally in the centre and convex on either side of this groove. Length: 3.5-4.5 mm.

Localities: Queensland: Holotype male [Reg. no. T6213], Lamington National Park, 28 January-3 February 1963, coll. G. Monteith (Q.M.); paratype male, Lamington National Park, *ex* leaf mould, 1 June 1955, coll. T. E. Woodward; 2 paratype males, 1 paratype female, Lamington National Park, 11-17 February 1963, coll. G. Monteith; 1 paratype female, National Park, 2-6 June 1958, coll. F. A. Perkins; 1 paratype female, Brisbane, 1954, coll. T. E. Woodward; 1 paratype female, Springbrook, 11 April 1955, coll. R. E. Harrison; 1 paratype female, Gordonbrook, 3 June 1959, coll. E. Exley; 1 paratype, abdomen and wings missing, Killarney, 11 November 1958, coll. I. C. Yeo; 2 paratype females, 1 paratype male, Atherton, 1 ♀ ex *Rondalesia* sp. 2 ♀ ♀ at light, 2, 4 and 19 October 1959, coll. G. Ettershank (U.Q.); 1 paratype female [Reg. no. I20,156], Mount Tambourine, coll. A. M. Lea (S.A.M.). New South Wales: Allotype female [Reg. no. I20,155], Dorrigo; 1 paratype female [Reg. no. I20,157], Upper Williams River, October 1926, coll. Lea and Wilson (S.A.M.); 1 paratype female, Dorrigo National Park, 30 May 1963, coll. G. Monteith (U.Q.); 1 paratype male, Wilson's Creek, near Mullumbimby, 29 January 1961, coll. D. K. McAlpine (A.M.). Victoria: 1 paratype female, Ferntree Gully, 26 July 1924, coll. F. E. Wilson (N.M.).

Brentiscerus pallidus sp. nov.

Plate 5, fig. C. Text fig. 1E

Head coarsely punctate, triangular, pale brown or yellowish brown, tylus protuberant and paler. Eyes blackish brown, inward of eyes on head on each side a prominent hair. First two antennal segments and apex of fourth yellowish, third and base of fourth brown. Rostrum reaching mid coxae, yellow, extreme apex somewhat infuscated. First segment of rostrum about reaching base of head, second fore coxae.

Pronotum with the usual transverse constriction about midway between base and apex, fore lobe mainly light brown except collar which is paler, extremely coarsely punctate; hind lobe almost luteous with dense coarse brown punctations, fore lobe posteriorly and hind lobe anteriorly impressed at the transverse impression to form a short longitudinal depression crossing the transverse suture. Anterior margin of pronotum straight or perhaps slightly concave, hind margin mainly straight but produced slightly and convexly behind the humeral angles, humeral angles somewhat elevated. Lateral margins convex at humeral angles, concave at region of transverse constriction and convex where bordering fore lobe.

Scutellum luteous, coarsely punctate with pale brown with the usual triradiate elevated keel.

Corium and clavus in the main luteous with coarse pale brown punctations, clavus with three rows, corium with two rows close to and parallel to claval suture, rest rather more scattered. Clavus between the median and outer rows of punctations, and corium in apical half (except three elongate included pale patches) infuscated with brown in the holotype, only vaguely so in the allotype. Membrane almost translucent.

Beneath light brown, anterior and posterior margins of propleura, hind margin of metapleura, lateral margins of abdomen and genital segments, all epimera and episterna, trochanters, and all the legs yellowish. Thorax coarsely punctate beneath, abdomen with a very sparse very short pilosity. Fore femora apparently unarmed.

Male genital capsule rather flattened above, upper opening partially divided into two cavities by two inwardly directed processes on the outer wall of the opening, claspers short, proctiger flattish on top and covering most of rear opening. Length: 2.20-2.25 mm.

Localities: Queensland: Holotype female and allotype male [Reg. nos. I20,158-9], Mount Tambourine, in rotting leaves, coll. A. M. Lea (S.A.M.).

Brentiscerus triocellatus sp. nov.

Plate 5, fig. D. Text fig. 1G

Head triangular, brown or black, coarsely punctate, anteclypeus (tylus) prominent, paler. First two segments of antennae and apical $\frac{2}{3}$ of fourth yellowish brown, third and base of fourth brown. Rostrum reaching mid coxae, basal segment not reaching base of head, first segment and extreme apex of fourth brown, remainder yellow or luteous.

Pronotum with the usual transverse constriction about midway between base and apex, with a strongly punctate anterior collar. Fore lobe (except collar) brown and coarsely punctate. Hind lobe stramineous or luteous with coarse brown punctations, a prominent brown semicircular patch on the hind margin on either side of the middle. Anterior lobe with a definite longitudinal depression which crosses the transverse suture and continues on to the anterior portion of the hind lobe. Hind margin feebly sinuate, humeral angles very slightly convex posteriad. Lateral margins strongly concave in the region of the transverse sulcus, anterior to this feebly convex, anterior margin straight or very feebly concave. Lateral keel stramineous or luteous.

Scutellum brown and coarsely punctate all over, with the usual triradiate keel, this sometimes lighter on terminus of each arm, or only lighter on the terminus of the central arm at apex.

Clavus stramineous or luteous with the usual three longitudinal rows of coarse punctations. Corium usually pale stramineous or luteous in the basal half, sometimes infuscated basally as in the figured specimen, but always infuscated with brown in the apical half, within this latter brown area three paler oval spots in a line near the hind margin. Membrane brownish hyaline, veins white.

Underside dark brown, collar, hind margins of pro- and metapleura and genital segment a shade paler. Trochanters and femora yellowish brown, apices of fore femora, tibiae, and tarsi yellowish, fore femora apparently unarmed. Underside of thorax strongly punctate, abdomen polished with a very sparse short pilosity. Male genital capsule with upper opening partially divided into two by inwardly

directed processes of the outer wall, claspers relatively short and robust. Proctiger grooved longitudinally in middle, covering most of hind cavity. Length: 2.25-3.0 mm.

Localities: Queensland: Holotype male, allotype female, 2 paratype males [Reg. nos. I20,160-3], Mount Tambourine, in rotting leaves, coll. A. M. Lea; 2 paratypes, one a male, other abdomen missing [Reg. nos. I20,164-5], Cairns District, attracted to light, A. M. Lea (S.A.M.); 2 paratype males, Lamington National Park, from leaf mould in rain forest, 2-6 June, 1958, coll. F. A. Perkins (U.Q.).

Brentiscerus diffusus sp. nov.

Plate 6, fig. A

Somewhat larger than *Brentiscerus triocellatus* but very similar in general appearance.

Head triangular, coarsely and densely punctate, tylus prominent, paler. First three segments of antennae *brown,* apical segment *entirely* luteous. Rostrum reaches midcoxae, first segment brown, remainder luteous.

Pronotum very similar in shape, punctation, and colouration to *B. triocellatus,* but collar entirely brown or black, like fore lobe; and hind lobe darker, the fuscous patches on the hind margin much larger, confluent in the centre.

Scutellum likewise formed and coloured as *B. triocellatus.*

Corium and clavus deep brown in colour, the former with a conspicuous pale patch on the outer margin midway between base and apex, and perhaps two vaguely lighter areas near hind margin, clavus with three rows of punctations, the region between the inner and median rows slightly raised, corium coarsely punctate, membrane brownish, veins paler.

Beneath deep brown to black (head, pro-, and meso-thorax), hind lobe of propleuron only paler. Femora in basal half brown, apically yellow, tibiae and tarsi yellow, fore femora armed with one small denticle beneath apically and a row of extremely small denticles on the anterior margin. Male not available for study of genitalia. Length: 3.25-3.5 mm.

Localities: Queensland: Holotype female and paratype female [Reg. nos. I20,166-7], Cairns District, attracted to light, A. M. Lea (S.A.M.).

Gastrodomorpha gen. nov.

A genus in the *Isopeltus, Brentiscerus* section of the tribe sharing with these genera the scutellum with a prominent triradiate keel and the sides of the pronotum with a prominent explanate keel; the pronotum is divided into two lobes by a prominent transverse impression about the middle. Like *Apollonius* the explanate lateral margins of the pronotum are straight but unlike *Apollonius* these margins are strongly convergent towards the front. Like the next, and last genus in this section (*Retrodrymus*) the lateral margins of the corium are convex, giving the insect the same pyriform appearance as a *Gastrodes*. The continuous lateral explanate margin of the pronotum should serve to distinguish it from the latter which does not occur in this area.

Head elongate, rather pentagonal, punctate, tylus strongly prominent. Antennae relatively thick, first segment surpassing apex of head. Rostrum attaining midcoxae, first segment not reaching base of head, second not quite reaching fore coxae.

Pronotum trapeziform, with a prominent collar, anterior margin somewhat concave, posterior very feebly so, with a prominent transverse constriction just behind the middle dividing it into two lobes. Lateral margins explanate from just behind collar to just before humeral angles, very feebly concave in the region of the transverse constriction and feebly convex in front of this, more noticeably so just behind the collar. Collar and hind lobe coarsely punctate and fairly densely so, fore lobe more finely and sparsely punctate.

Scutellum triangular with a prominent triradiate keel, coarsely and densely punctate all over.

Corium and clavus coarsely punctate, clavus with the usual three rows, corium with the punctations arranged in more distinct rows than in the other genera, longitudinal veins also more distinct. Lateral margin of corium straight in basal third, thence convex to apex, hemelytra widest at about level of apex of claval suture. Membrane just reaching apex of abdomen.

Fore femora incrassate, armed on ventral surface with an anterior and posterior row of spines in the apical third, the innermost spine of the anterior row large. Male capsule unknown.

Type: *Gastrodomorpha enigmatica* sp. nov. the only species.

Gastrodomorpha enigmatica sp. nov.

Plate 6, fig. D

Head coarsely punctate, blackish brown, apex of anteclypeus (tylus) lighter. Eyes remote from anterior margin of pronotum. Antennae with first three segments brown, fourth missing. Rostrum yellowish.

Fore lobe of pronotum including collar brown, explanate margins and hind lobe yellowish, punctations on latter light brown.

Scutellum yellowish, punctations and extreme base light brown.

Corium and clavus yellow, punctations light brown, some vague indications of fuscous in the apical portions of the former. Membrane brown, veins lighter.

Beneath brown, posterior margins of pro- and meta-pleura lighter, legs yellow. Thoracic pleura with few punctations in centre of disc, abdomen shiny with short adpressed golden pilosity. Length: 3.2 mm.

Locality: Victoria: Holotype female [Reg. no. I20,168], Ringwood, in tussocks, coll. F. E. Wilson (S.A.M.).

Retrodrymus gen. nov.

Retrodrymus is the last of the genera with an explanate margin to the pronotum and a prominent triradiate keel to the scutellum. It differs from the other genera in this group by having the transverse constriction of the pronotum placed well posteriad, and by a larger and more convex fore lobe of the pronotum.

Head elongate, pentagonal, rugose, anteclypeus (tylus) strongly prominent, eyes remote from anterior margin of pronotum. Antennae relatively robust, first segment surpassing apex of head, second segment the longest, third a little shorter than second, fourth a little shorter than third and only slightly longer than first. Rostrum reaches hind coxae, first segment not reaching base of head, second segment just attaining fore coxae.

Pronotum rather elongate with a prominent coarsely punctate collar, feebly impressed well behind midline, the division of pronotum into fore and hind lobes is achieved not so much by a strong transverse impression as in most Drymine genera but rather by the termination posteriorly of the strongly convex fore lobe onto the general plane of the hind lobe. Fore lobe finely but fairly densely punctate,

hind lobe densely and coarsely punctate. Anterior margin of pronotum truncate or faintly convex, hind margin almost straight. Lateral margins explanate from behind collar to just in front of humeral angles, this lamina narrow and convex in outline around raised fore lobe, very slightly concave at the division of the fore and hind lobes, and faintly divergent to humeral angles.

Scutellum triangular, coarsely punctate and with a very prominent triradiate keel.

Corium and clavus strongly punctate; clavus with the usual three rows of punctations, corium narrowly impunctate exteriorly in the basal half, this region rather reflexed, punctate area with punctations tending to be arranged in rows. Outer margin of corium gently convex from base to apex, animal widest at a point about midway between apex of scutellum and apex of claval suture. Membrane somewhat surpassing apex of abdomen.

Beneath with propleura and metapleura strongly punctate, metapleura punctate only in centre of disc. Fore femora relatively incrassate, beneath anteriorly with a row of about seven spines in the apical *third,* first of these very large, posteriorly with a row of small spines in apical *half.*

Male genital capsule with upper opening partially divided into two by two inwardly directed processes on outer margin, claspers relatively long, sides of opening behind claspers with long hairs.

Type: *Retrodrymus abundans* sp. nov., the only species in the genus.

Retrodrymus abundans sp. nov.

Plate 5, fig. A. Text fig. 1A, H

Head brown to black, apex of tylus luteous when head brown, and brown when head black. First two segments of antennae yellowish in brown headed specimens and apical two segments brown; in black headed specimens basal two segments brown and apical pair dark brown. Rostrum yellowish in brown headed specimens, yellowish brown in black headed specimens, basal segment somewhat darker, especially basally.

Swollen fore lobe of pronotum including collar brown when head brown, black when head black; hind lobe testaceous, lighter laterally, humeral angles and lateral keel luteous.

Scutellum yellowish or brownish depending on the colour of the head and fore lobe of the pronotum, when brownish the apices of the three arms of the triradiate keel luteous. Punctations brown.

Corium and clavus yellowish or brownish according to the darkness of the general colouration, with a transverse infuscated bar across corium, somewhat oblique at a level midway between the apex of the scutellum and the apex of the claval suture. Membrane a deep brown, veins somewhat lighter.

Underside of head and thorax blackish brown, abdomen deep brown, trochanters, femora, tibiae and tarsi yellowish. Length: 4.25-5 mm.

Localities: Tasmania: Holotype male mounted on card with nymph, one paratype male, three paratype females [Reg. nos. 120,169-73] Devonport, coll. Lea; 2 paratype males, 2 paratype females [Reg. nos. I20,174-7], Waratah, coll. Lea & Carter; 1 paratype male [Reg. no. I20,178], Ulverstone, coll. Lea (S.A.M.). Victoria: Allotype female, Macedon, coll. Deane; one paratype male 3 paratype females, Eltham, coll. J. E. Dixon; 1 paratype female, Evelyn, 17 May 1925, coll. F. E. Wilson; 1 paratype female, Emerald District, coll. E. J.; 2 paratype females, 1 paratype male, Ferntree Gully, 20 November 1920, 26 July 1924, 26 May 1925, coll. F. E. Wilson; 1 paratype female, Ferntree Gully, coll. J. E. Dixon; 2 paratype females, Western Districts (N.M.).

Appolonius Distant 1901

Appolonius Distant 1901, Ann. Mag. nat. Hist., (7)8: 484. 1904, Fauna Brit. India Rhynch. 2: 62. Scudder 1956, Ent. mo. Mag. (4)17: 359. 1957, *loc. cit.*: 154.

Agunga Distant, 1906, Ann. Soc. ent. Belg., 50: 413. 1910, Fauna Brit. India Rhynch., 5: 58.

Appolonius is the first of a series of genera in which the pronotum has a prominent transverse impression and the lateral margins are explanate but in which the scutellum is *devoid* of a prominent raised triradiate keel, in *Appolonius* the scutellum is somewhat raised medially. It differs from the other genera in this section by its nearly rectangular pronotum with almost straight lateral margins.

Head broad, short, triangular, without eyes as broad as anterior margin of pronotum. Eyes large, prominent, touching anterior margin of pronotum. Antennae inserted well away from eyes, robust, first

segment not or only just surpassing apex of head, all segments relatively short, rostrum just reaching fore coxae (*crassus* (Distant) from India), or reaching mid coxae (other species).

Pronotum strongly quadrate, with a strong transverse impression about the middle. Anterior margin straight (*quadratus* Scudder *crassus* (Distant) and *picturatus* Distant), or strongly convex (*cinticornis* Distant, *territorialis* n.sp. and *robustus* n.sp.), hind margin almost straight. Lateral margins explanate, almost straight and converging in the two Australian species, somewhat concave in the region of the transverse impression in the extra-Australian species, anterior lobe swollen and finely punctate, hind lobe flattish or arched and more coarsely punctate.

Scutellum transversely impressed across base, medially somewhat raised, finely punctate like fore lobe of pronotum.

Corium and clavus coarsely punctate, clavus with the usual three longitudinal rows of punctations, punctations on corium more or less arranged in rows, including 1½-2 rows paralleling claval suture. Lateral margins of corium almost straight, very feebly sinuate. Fore femora very incrassate, apically beneath with one large tooth followed by five or six spines.

Male capsule of *territorialis* only investigated. There is the usual partial division of the upper opening into two by acute inwardly directed projections of the lateral margins, the claspers are flat on top and pointed, the proctiger covers most of the anterior cavity, but in addition there are two larger rugose or punctate flaps lying over this and originating from the lateral margin, strongly reminiscent of *Drymus* species.

Type: *Ophthalmicus cincticornis* Walker 1872, monobasic.

There are two Australian species which can easily be distinguished from the extra-Australian species by the almost straight lateral margins of the pronotum.

Appolonius territorialis has the second and third femora pale yellow and the dark markings in the apical region of the corium are relatively fine, *A. robustus* has brown femora except at apex, is wider in relation to its length, and the dark markings in the hind partion of the corium are broader, the hind lobe of the pronotum is also more fuscous.

Appolonius territorialis sp. nov.

Plate 6, fig. B. Text fig. 1I

Head dark brown, finely punctate, eyes brown. First two antennal segments yellow, apical pair brown. Rostrum yellowish, basal segment and basal third of second browner.

Anterior lobe of pronotum dark brown, finely punctate, hind lobe and lateral explanate margin luteous, the former with four faint brown longitudinal lines, one either side of the midline, sometimes fusing into one broad median band and another close to each lateral margin.

Scutellum deep brown, almost black, finely punctate, medially raised, transversely impressed near base.

Corium and clavus luteous with brown punctations, the former with two fuscous spots on the lateral margin, one in the middle, one in the apical angle and between these a prominent luteous spot. Apical margin of corium infuscated giving off three thin fuscous lines running more or less anteriorly, these are joined to one another where they terminate, the outer the longest and running into the medial marginal spot. Clavus with a brown streak in the distal half between the median and outer line of punctations. Membrane greyish hyaline, veins brown.

Thorax beneath deep brown, prothorax and mesothorax strongly punctate, metathorax with only a longitudinal band of punctations near exterior margin, lateral keel of prothorax luteous; beneath hind margin of propleura and metapleura and episterna and epimera a lighter shade than the rest of the thorax. Abdomen shining brown with a fine golden pilosity. Fore femora and all coxae brown, rest of legs yellowish. Length: 3.0-3.5 mm.

Locality: Northern Territory: Holotype male and 1 paratype male [Reg. nos. I20,179-80], Batchelor, on fruit of Roselle (*Hibiscus sabdariffa*), 20 October 1913, coll. presumed G. F. Hill (S.A.M.).

Appolonius robustus sp. nov.

Plate 6, fig. C

Head almost black finely punctate, eyes brown. First two segments yellowish, though apical third of second darker, terminal two segments deep brown, apex of last a shade paler. Rostrum brown.

Pronotum near black, lateral explanate margin luteous only at, and anterior to, level of transverse impression. Hind lobe with raised humeri and two oblique lines somewhat inward of these, not reaching transverse impression, paler. Anterior lobe finely punctate, posterior lobe more coarsely so.

Scutellum formed and coloured substantially as in the previous species.

Corium and clavus basically luteous, clavus marked as in *territorialis*. Corium with two prominent fuscous marks on the exterior margin, one in the middle and the other apical, this latter large and extending along the whole of the posterior margin of the corium, these two lateral marks joined by a fuscous line. Corium with three other fuscous lines, one given off in the middle of the widely black hind margin runs forward to end freely, of the other two one is given off about $\frac{1}{3}$ out from the apex of the clavus and the other right at the clavus to meet at about the level of the tip of the scutellum, the inner one running along the claval suture in its apical third, the other curving inward to meet it, within these lines a prominent silvery patch. Membrane hyaline grey, veins brown.

Thorax and abdomen beneath almost black, the former punctate as in *A. territorialis*, the latter with a whitish pilosity. All femora brown except at extreme base and apex, tibiae and tarsi yellow. Length: 3.25-3.5 mm.

Localities: Queensland: Holotype male [Reg. no. I20,181], Magnetic Island, coll. A. M. Lea (S.A.M.); allotype female, Brisbane, 15 May 1954, coll. K. L. S. Harley; paratype female, Brisbane, on bark of *Ficus* (Indian fig), 16 May 1951, coll. T. E. Woodward (U.Q.).

Scolopostethus Fieber 1861

Scolopostethus Fieber, 1861, Europ. Hem. :49, 188. Stål, 1872, Öfv. svenska Vetensk Akad. Förh. 29(7): 60. Saunders, 1892, Hem. Het. Brit. Is. :108. Horvath, 1902, Rev. d'Ent., 11: 253. Lethierry & Severin, 1894, Cat. gén. Hém., 2: 228. Distant, 1903, Fauna Brit. Ind., Rhynch., 2: 92. Guerin & Penau 1906, Rennes Bul. Soc. Sci. méd., 14: 67. Horvath, 1911, Ann. Mus. nat. Hung., 9: 337. Van Duzee, 1917, Univ. Cal. Publ. Ent. 2: 199. Southwood & Leston, 1959, Land and Water Bugs Brit. Is., :89. Slater & China, 1961, Bull. Zool. Nomencl., 18(5): 351.

Tritomacera Costa 1841, Ann. Soc. ent. France (1)10: 296-297. Fieber, 1861, Europ. Hem. 44: 163.

Tritomocera Agassiz, 1846, Nomen. zool. Index. Univ. :376.

Tritomacera 1848 *ibid.* 1092.

Manatanus Distant, 1909, Ann. Mag. nat. Hist., (8)3: 494. 1910, Fauna Brit. Ind. Rhynch., 5: 86.

Head triangular, anteclypeus (tylus) prominent, eyes not quite touching anterior margin of pronotum, first segment of antennae just (new species described here), or considerably passing apex of head; rostrum reaching middle coxae.

Pronotum quadrate or trapezoidal, lateral margins straight or sinuate in region of the strong transverse constriction which is placed about half way back, lateral margins explanate. Anterior and posterior margins straight or concave.

Scutellum triangular, somewhat tumid, without any trace of a triradiate keel.

Clavus with the usual three rows of punctations, corium with two rows parallel to the claval suture and the rest for the most part scattered in the apical area, lateral margins of coria feebly sinuate.

Thorax beneath strongly punctate, abdomen shiny, finely pilose. Anterior femora incrassate with a large spine ventrally just outward of the halfway point and a series of smaller spines between it and the apex. Fore femora somewhat curved, in the male enlarged apically and bearing several teeth. First segment of hind tarsi longer than segment two and three together.

Type: *Scolopostethus cognatus* Fieber 1860, selected by Distant 1904 (*loc. cit.*).

This appears to be a complex and rather ill characterized genus, some of the species appear to be among the most contrasting coloured in the Drymini. It is with some hesitation that I place the following species in the genus, considering its short and robust antennae.

Scolopostethus forticornis sp. nov.

Plate 7, fig. A. Text fig. 1J

Head piceous, upper surface finely punctate, apex of tylus and eyes lighter. Antennae brown, apical half of first segment and sometimes apices of second and fourth yellowish. Antennae short, first

segment just surpassing apex of head. Rostrum yellowish, thin, first segment just surpassing apex of head.

Pronotum piceous to rather velvety brown, finely and fairly densely punctate, punctations tending to be difficult to see, in some specimens hind lobe a shade paler than fore lobe. Explanate lateral margins concolorous with rest of pronotum, somewhat sinuate in region of transverse pronotal constriction and broadly convex in front of this to region of collum. Hind margins almost straight, anterior margin concave.

Scutellum somewhat convex, velvety piceous or brown, finely punctate.

Apical $\frac{2}{3}$ of corium and apical half of clavus piceous or brown, basal area of clavus and corium and a lateral spot on the latter about $\frac{2}{3}$ the way along the outer margin luteous, apical margins of the clavus and along the claval suture also yellowish in some specimens. Punctations only distinct in luteous areas and brown. Membrane apically generally piceous with a large luteous semilunate spot at the base occupying the whole of the basal margin and extending about $\frac{1}{3}$-$\frac{1}{2}$ way along the inner margin, this spot interrupted by a hook shaped piceous mark near its inner basal area.

Beneath piceous to deep brown, fore femora brown, apex lighter, rest of legs rather yellowish brown, tibiae somewhat darker.

Male genital capsule with upper opening partially divided into two by inwardly directed processes on the outer margin, claspers flat, somewhat upturned apically, anterior cavity almost wholly covered by longitudinally impressed pygophore. Length: 3.25-4.25 mm.

Localities: South Australia: Holotype male, allotype female, 1 paratype male [Reg. nos. I20,182-4], Lock 4, River Murray, under red gum (*Eucalyptus camaldulensis*) bark, 18 May 1964, coll. G. F. Gross; 1 paratype male, 1 paratype female [Reg. nos. I20,185-6], Wilpena Pound, Coll. H. M. Hale; 1 paratype male [Reg. no. I20,187], Pt. Lincoln, coll. A. M. Lea (S.A.M.). Victoria: 4 paratype males, 6 paratype females, Lake Hattah, coll. J. E. Dixon (N.M.). Queensland: 1 paratype (genitalia missing), Gayndah, coll. Masters (A.M.).

Pseudodrymus gen. nov.

Body oblong or oval, rugosely punctate, generally blackish. Head with eyes touching or a little separated from anterior margin of pronotum, head triangular, tylus very prominent. Pronotum relatively

short, generally narrower anteriorly than posteriorly with a shallow transverse constriction rather behind the middle, anterior margin straight or concave, posterior margin likewise variable, lateral margins generally rather concave in region of transverse impression, convex in front of this, lateral margins acute, only very narrowly explanate.

Scutellum triangular, convexly raised near base but without a trace of a triradiate keel.

Hemelytra (except membrane) strongly and coarsely and very densely punctate, slightly convex above.

Fore femora swollen and armed near apex with a short spine, exterior to that several smaller ones.

Male genital capsule with upper opening strongly constructed into two lobes by acute inwardly directed processes of the outer wall, claspers large and flat, proctiger covering most of anterior cavity.

Type: *Pseudodrymus florestalis* n.sp., the only species in the genus.

Pseudodrymus florestalis sp. nov.

Plate 7, fig. B. Text fig. 1K

Black or piceous, very coarsely and very densely punctate above. Apical half of terminal antennal segment, explanate lateral margin of pronotum basally, and hind lobe of pronotum vaguely, and sometimes corium laterally rather paler. Several specimens in the series are all castaneous.

Head triangular, tylus acute, antennae with a rather long-pilosity, some of it longer than the width of the segments. Rostrum thin, reaching mid coxae.

Transverse impression of pronotum shallow, fore lobe quite low, anterior and posterior margins almost straight, lateral margins only feebly sinuate in the region of the transverse impression.

Scutellum rather strongly excavate at extreme base, behind this usually transversely swollen.

Corium and clavus extremely densely and coarsely punctate, former somewhat convex and veins distinct. Membrane dark grey brown, veins lighter.

Beneath with thorax strongly punctate, abdomen shining with a dense golden pilosity, especially apically. Fore femora swollen and armed with one short spine near the apex, with one or two extremely minute teeth on both ventral margins near it.

Parandria of male genital capsule rather triangular in shape and fairly smooth. Length: 2.75-3.2 mm.

Localities: Queensland: Holotype female [Reg. no. T6214, in Q.M.], 4 paratype females, Whiteside Crossing, N. Pine River S.E. Queensland, in flood debris, 12 July 1963, coll. G. Monteith; allotype male, S.E. Queensland, 1963, coll. G. Monteith; 1 paratype female, Noosa District, on sand dunes under herbs and fallen leaves of *Casuarina,* 17 April 1960, coll. T. E. Woodward. Western Australia: 2 paratype males, 5 paratype females, Morley Park, Perth, ex dead *Banksia* leaves, 27 August 1959, coll. T. E. Woodward (U.Q.); 1 paratype male, King George's Sound (A.M.).

Austrodrymus gen. nov.

Obovate, very strongly punctate. Head broad, triangular, rather conical in side view, strongly punctate, clypeus not very obvious. Antennae relatively robust, first segment barely or not surpassing apex of head. Rostrum about reaching mid coxae, first segment conspicuously thicker than rest, reaching base of head.

Pronotum very strongly punctate, with a shallow transverse constriction placed well *behind* the middle, anterior and posterior margins somewhat convex, lateral margins more broadly laminate than in *Drymus,* straight from base to about middle of fore lobe, thence convex anteriorad. Anterior lobe rather low, both lobes strongly and closely punctate.

Scutellum triangular, strongly and closely punctate, fairly flat, raised slightly basally and medially, these two raised areas separated by a feebly marked transverse groove.

Corium and clavus punctate, the latter with the usual three longitudinal rows, those on the corium tending to be arranged in rows, the innermost two close together and paralleling the claval suture, the outermost row parallel to the narrow and impunctate exterior margin.

Underside of thorax very strongly and closely punctate, abdomen shiny with a rather long adpressed pilosity, particularly apically.

Fore femora rather incrassate and armed near apex with a small tooth and apically to this some five much smaller spines.

Male genital capsule with upper opening partially divided in two by inwardly directed lobes of the outer wall, claspers pointed, proctiger covering all of hind cavity and longitudinally grooved in the middle.

Type: *Austrodrymus flindersi* sp. nov., the only species.

Austrodrymus flindersi sp. nov.

Plate 7, fig. C. Text fig. 1L

Head, anterior lobe of pronotum, and scutellum piceous to dark brown. Basal two thirds of first segment of antennae, hind lobe of pronotum, and tip of scutellum brown, so also hind margin of corium, a rectangular mark enclosing a pale smaller rectangular mark in the inner apical angle of the corium, and a short longitudinal line given off from about midway along the hind margin and directed anteriorly. Remainder of corium, clavus, laminate lateral margin of pronotum, apex of first antennal segment, and remaining segments yellowish brown. Membrane pale whitish yellow.

Underside deep brown to brown, rostrum and legs a somewhat lighter brown. Length: 2.5-2.75 mm.

Localities: South Australia: Holotype male [Reg. no. I20,188], Flinders Island, coll. T. D. Campbell (S.A.M.). Western Australia: 1 paratype male, Morley Park, Perth, from dead *Banksia* leaves, 27 August 1959, coll. T. E. Woodward.

Brachydrymus gen. nov.

Obovate, head pronotum and hemelytra strongly rugulose, scutellum punctate. Head triangular, eyes almost touching anterior pronotal margins, clypeus not prominent. Antennae fairly slender, first segment just surpassing apex of head. Rostrum reaches mid coxae, first segment not attaining base of head.

Pronotum rather quadrate, broad, with very little trace of a transverse pronotal constriction and that placed well behind the middle. Anterior and posterior margins rather concave, lateral margins acute but hardly laminate, straight in basal $\frac{2}{3}$, convex anteriorly. Pronotum densely rugulose and shortly pilose all over.

Scutellum flat, triangular, rather more punctate than rugulose, with a scattered short pilosity.

Hemelytra micropterous, extending only to two thirds the length of the abdomen, membrane absent, claval suture difficult to see, whole surface of hemelytra rugulose with a short pilosity. Exposed dorsal surface of abdomen similarly rather rugulose and with the same short pilosity.

Underside of thorax strongly rugose except for blackish hoary evaporative area. Abdomen rugulose beneath with a scattered short pilosity.

Fore femora mederately incrassate, very finely rugulose, apparently without spines. Male genital capsule rugulose posteriorly, with upper opening feebly constricted into two and with membraneous proctiger concealing the vesica. Claspers shortish, rather robust.

Type: *Brachydrymus lateabundans* sp. nov. the only species.

Brachydrymus lateabundans sp. nov.

Plate 7, fig. D. Text fig. 1M

Dorsal surface piceous, pilosity silverish. Antennae, rostrum, eyes and legs dark brown, in one specimen the hemelytra are also somewhat paler than the rest of the body.

Remaining features as for generic diagnosis. Length: 2.50-3.50 mm.

Localities: Victoria: Holotype male, allotype female, 1 paratype female, Ferntree Gully, 26 April 1924, coll. F. E. Wilson; 1 paratype male, 1 paratype female, Ferntree Gully, 28 September 1914, coll. J. E. Dixon; 2 paratype males, 1 paratype female, Croydon, coll. J. E. Dixon (N.M.). Queensland: 1 paratype female [Reg. no. I20,189], Gladstone, coll. A. M. Lea. Northern Territory: 1 paratype female [Reg. no. I20,190], Darwin in soil and leaf litter near sports oval, 8 December 1960, coll. R. V. Southcott (S.A.M.).

DISCUSSION

This tribe of Rhyparochrominae is undoubtedly a very difficult one in which to characterize generic differences and relationships.

On the basis of external characters there would appear to be three groups in this fauna. The first group represented by the one genus *Mizaldus* lacks entirely lateral explanate carinae to the rather convex pronotum. A second group has lateral explanate carinae or laminae to the pronotum and a prominent triradiate keel to the

scutellum, and would include *Paradrymus, Megadrymus, Isopeltus, Brenticerus* and *Gastrodomorpha.* A third group has prominent lateral explanate laminae to the pronotum but lacks entirely any sign of a triradiate keel on the scutellum, although the centre of the scutellum may be raised. In this group fall *Apollonius, Scolopostethus, Pseudodrymus* and *Austrodrymus. Brachydrymus* seems to be a modified member of the last group where flattening of the pronotum has resulted in an almost complete elimination of the lateral laminae.

An examination of the dorsal morphology of the male genital capsule complicates this picture somewhat. The typical arrangement is for the upper opening to be constricted into somewhat of an 8 shape by inwardly directed protuberances, one on each of the opening. The anterior cavity is always larger than the posterior one so formed. In Australian species a prominent and moderately chitinized proctiger always covers most of the anterior cavity and is located a little below the level of the outer walls, in many species this is depressed along the median longitudinal line and the structure rises rather convexly on either side of this depression to meet the outer margin of the cavity. Two claspers or parameres are present in the posterior cavity, becoming apparent just behind the inwardly directed processes of the outer wall. In most Australian species they are fairly short and pointed but in *Pseudodrymus* rather flattened.

Two genera differ somewhat from this general type. The male capsule of *Megadrymus* is rather differently shaped and has short very acuminate claspers swollen basally and the capsule has prominent pilose ridges apically on either side of the middle. The male capsule of *Appolonius* has two prominent rugose flaps or parandria given off from the side wall of the hind cavity (this cavity is much larger than the anterior one in this genus) which partially overlap and which cover part of the proctiger. These flaps are also present in British species of *Drymus* Fieber and in the subgenus *Sylavadrymus* Le Quesne, their bases do not cover their point of attachment as in *Appolonius* (Le Quesne 1956, Ent. mon. Mag., 4(202): 337-341, or 92(4): 17. The capsule of *Appolonius* was the only one cleared and permanently mounted in this study; the others were examined under the highest powers of the binocular microscope after hydroxide treatment of the tip of abdomen and extrusion of the capsule by light pressure. In the cleared mount of *Appollonius* more of the basal structure of the male claspers can be seen and in general the structure resembles Le Quesne's figures 19, 21 and 23. Males of *Mizaldus* and *Gastrodomorpha* were not available for examination.

REFERENCES

Agassiz, L., 1846: Nomenclatoris Zoologici Index Universalis.

——— 1848: Nomenclatoris Zoologici Index Universalis I-X: 1-1133.

Bergroth, E., 1916: New Genera and species of Australian Hemiptera. Proc. roy. Soc. Vict., (N.S.) 29(1): 1-18.

——— 1918: Studies in Philippine Heteroptera, 1. Phillipp. J. Sci. (d) 13(2 & 3): 43-126.

Distant, W. L., 1901: Rhynchotal Notes—XI. Heteroptera: Family Lygaeidae. Ann. Mag. nat. Hist., (7)8: 464-486 & 497-510.

——— 1903 & 1904: The Fauna of British India including Ceylon and Burma. Rhynchota. 2, i-xvii & 1-242 (1903) and 243-503 (1904). 319 text figs.

——— 1906-7: Oriental Heteroptera. Ann. Soc. ent. Belg., 50: 405-417.

——— 1909: Oriental Rhynchota Heteroptera. Ann. Mag. Nat. Hist. (8)3: 491-507.

——— 1910: The Fauna of British India including Ceylon and Burma. Rhychota, 5: i-xvii and 1-362. 214 text figs.

Fieber, F. X., 1861: Die europaischen Hemiptera. Halbflugler. (Rhynchota Heteroptera.) Nach der analytischen Methode bearbeitet. Wien I-VI. 1-444. 2 tables.

Guerin, J. & Peneau, J., 1906: Faune entomologique armoricaine. Lygaeides. Bull. Soc. sci. méd. Ouest, 14: 1-84. 166 text figs.

Horvath, G., 1902: Rev. d'Ent. 11: 253.

——— 1911: Miscellanea Hemipterologica. Ann. hist-nat. Mus. hung. 9: 1-34, 327-338, 423-435, table IX.

Le Quesne, W. J., 1956: An Examination of the British Species of *Drymus* Fieber (Hem., Lygaeidae) with a New Subgenus and an Addition and a Generic Reassignment in the British List. Ent. mon. Mag. 92(4)17: 337-341. 28 text figs.

Lethierry, L. & Severin, G., 1894: Catalogue général des Hémiptères. Bruxelles. Tome 2: 1-277.

Saunders, E., 1892: The Hemiptera of the British Islands. A descriptive account of the families, genera and species indigenous to Great Britain and Ireland, with notes as to localities, habitats, etc.: i-v, 1-350. 1 plate.

Scudder, G. G. E., 1956: A revision of the genus *Appolonius* Distant (Hemiptera, Lygaeidae) with a New Species from South Sudan. Ent. mon. Mag., 92: 359-360.

——— 1957: The higher classification of the Rhyparochrominae (Hem. Lygaeidae). Ent. mon. Mag., 93: 152-156.

——— 1962: The World Rhyparochrominae (Hemiptera-Lygaeidae) II. New Genera for Previously Described species. Canad. Ent., 94(9): 981-989, 10 text figs.

Slater, J. A. & Carayon, J., 1963: Ethiopian Lygaeidae IV. A New Predatory Lygaeid from Africa with a Discussion of its Biology and Morphology. (Hemiptera: Heteroptera). Proc. R. Ent. Soc. Lond. (A)38(1-3: 1-11. 10 text figs.

Slater, J. A. & China, W. E., 1961: *Scolopostethus* Fieber (1860) (Insecta, Hemiptera): Proposed Validation under the Plenary Powers. Z.N.(S) 1475. Bull. zool. Nomencl. 18(5): 351-352.

Stål, C., 1872: Genera Lygaeidarum Europae disposuit. Öfvers. Vetensk Akad. Förh., Stockh. 29(7): 37-62.

Southwood, T. R. E. & Leston, D., 1959: Land and Water Bugs of the British Isles. London, I-XI, 1-436, 153 text figs. 63 plates.

Van Duzee, E. P., 1917: Catalogue of the Hemiptera of the America North of Mexico, excepting the Aphididae, Coccidae and Aleurodidae. Univ. Calif. Publ. Ent., 2: i-xiv, 1-902.

Walker, F., 1872: Catalogue of the Specimens of Hemiptera Heteroptera in the Collection of the British Museum. Brit. Mus. Pub., Pt. V: 1-202.

RESUME

On connaissait antérieurement deux espèces de Drymini de l'Australie et une de la Nouvelle-Guinée. Comme resultat de cet étude, où on a employé toutes les collections disponibles australiennes, on a demonstré l'occurrence de deux espèces dans la Nouvelle-Guinée, une d'elles est espèce commune dans l'Australie, et de dix-sept espèces, dont

quinze sont nouvelles, de l'Australie. On donne des clefs, des illustrations, et des descriptions des dix-huit espèces et les met dans douze genres, dont huit sont nouveaux. Où disponible on a employé la morphologie de la capsule mâle genitale en conjunction de details exterieurs pour donner une indication a l'arrangement et à les rélations entre ces douze genres.

EXPLANATION OF PLATES 3 TO 7

PLATE 3

Fig. A. *Paradrymus exilirostris* Bergroth, whole insect.
Fig. B. Fore leg of *Paradrymus exilirostris* Bergroth, female.
Fig. C. Fore tibia of *Paradrymus exilirostris* Bergroth, male.
Fig. D. *Megadrymus terraereginae* n.sp.

PLATE 4

Fig. A. *Mizaldus woodwardi* Slater & Carayon.
Fig. B. *Isopeltus australis* (Bergroth).
Fig. C. *Brentiscerus major* n.sp.
Fig. D. *Isopeltus obscurus* n.sp.

PLATE 5

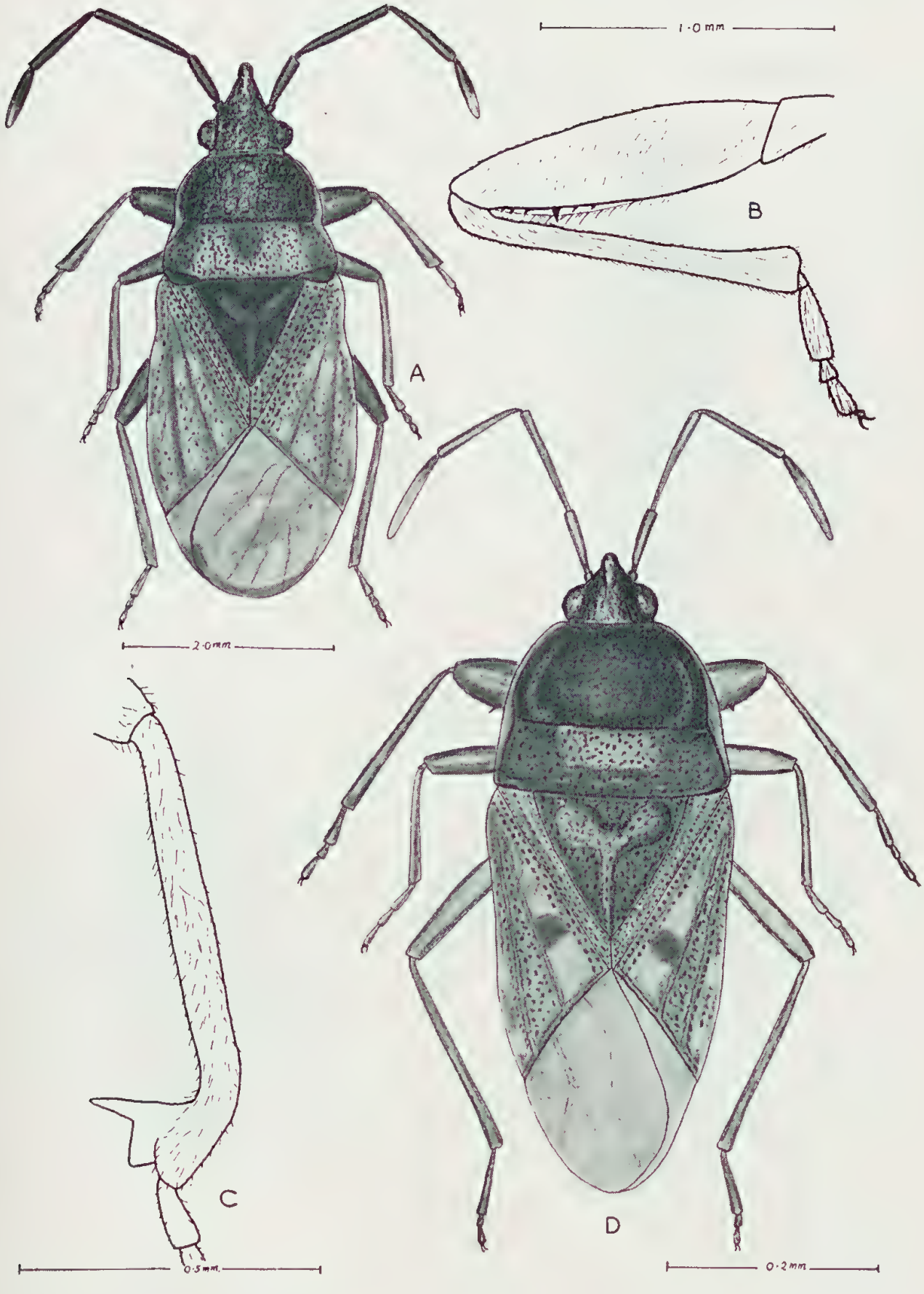
Fig. A. *Retrodrymus abundans* n.sp.
Fig. B. *Isopeltus tenuicornis* n.sp.
Fig. C. *Brentiscerus pallidus* n.sp.
Fig. D. *Brentiscerus triocellatus* n.sp.

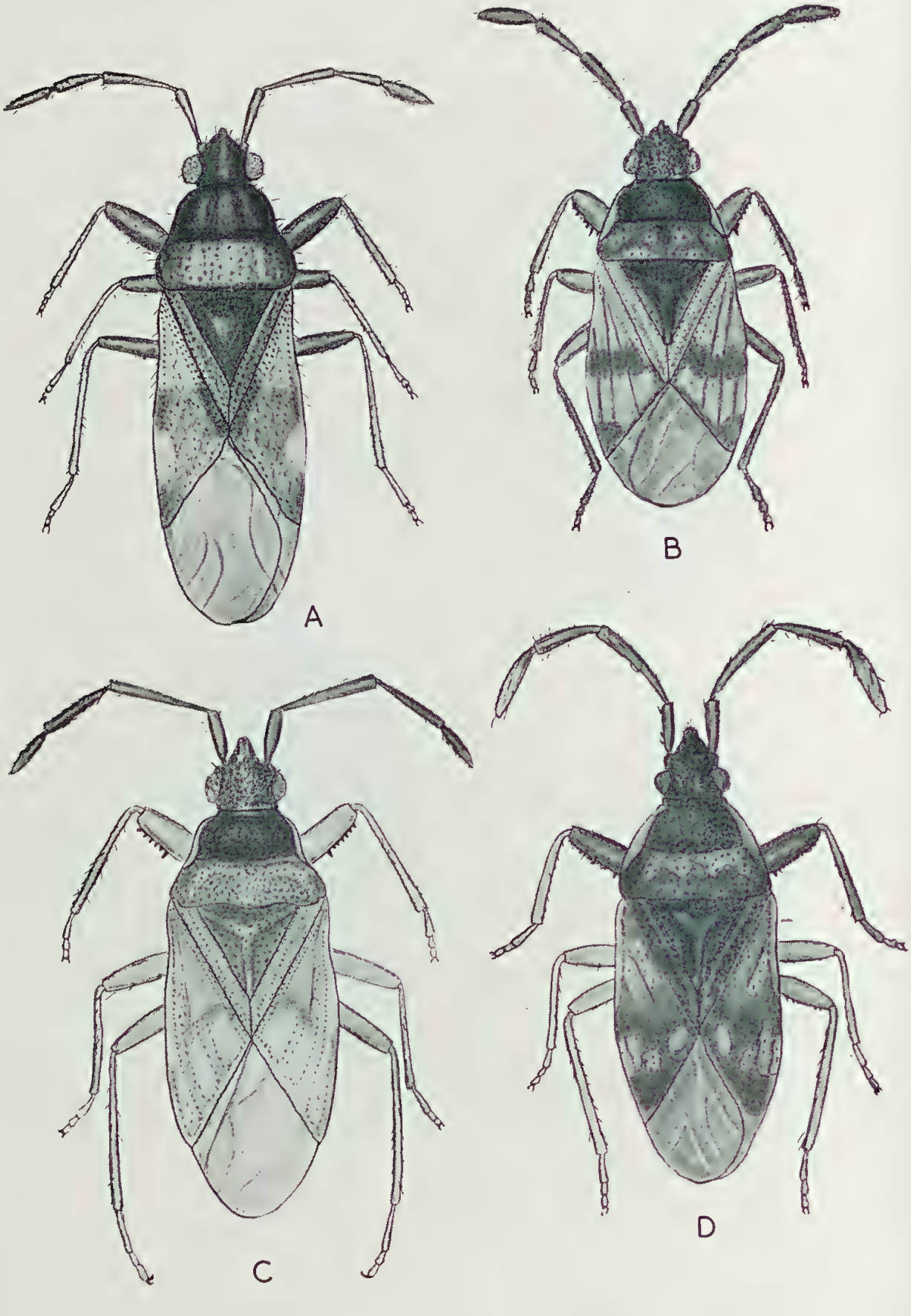
PLATE 6

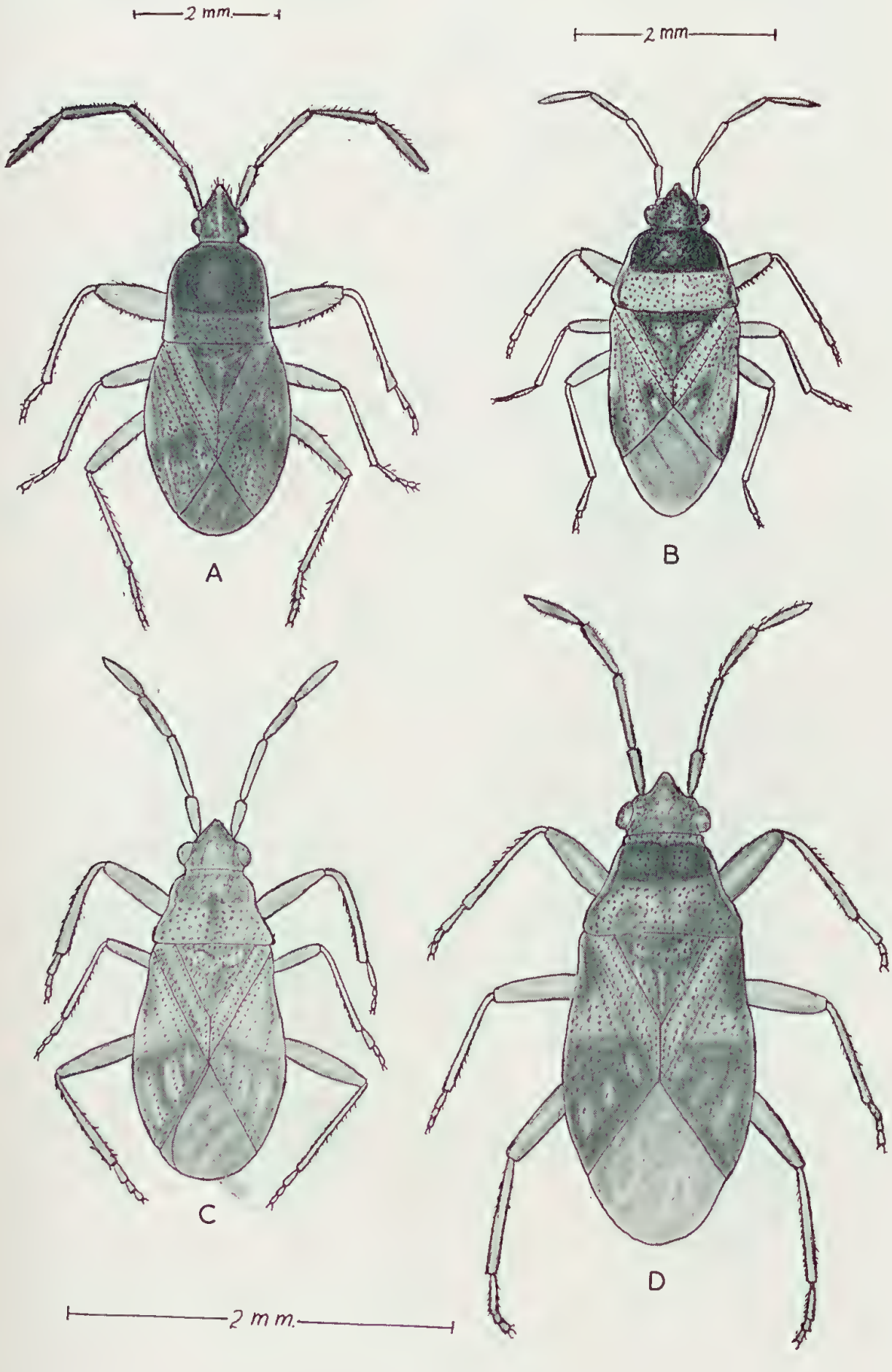
Fig. A. *Brentiscerus diffusus* n.sp.
Fig. B. *Appolonius territorialis* n.sp.
Fig. C. *Appolonius robustus* n.sp.
Fig. D. *Gastrodomorpha enigmatica* n.sp.

PLATE 7

Fig. A. *Scolopostethus forticornis* n.sp.
Fig. B. *Pseudodrymus florestalis* n.sp.
Fig. C. *Austrodrymus flindersi* n.sp.
Fig. D. *Brachydrymus lateabundans* n.sp.


1·0 mm
A
B
2·0 mm
C
0·5 mm
D
0·2 mm


A
B
C
D
2 mm.


2 mm
2 mm
A
B
C
D
2 mm

2mm.
2mm.
A
B
C
D
2mm.
2mm.

2mm.
A
B
C
1·0mm.
D

CHROMOSOMES OF SNAILS INTRODUCED INTO SOUTH AUSTRALIA AND THE NORTHERN TERRITORY

By HELENE M. LAWS, South Australian Museum

Plate 8

SUMMARY

The chromosome complement is described for seven members of the family Helicidae (Pulmonata, Helicacea) which have been introduced into South Australia and for one member of the Subulinidae (Pulmonata, Achatinacea) introduced into the Northern Territory. Haploid chromosome numbers from counts made in primary spermatocytes are as follows: *Helix aspersa*, n = 27; *Theba pisana*, n = 30; *Helicella virgata*, n = 26; *H. stolismena*, n = 26; *H. neglecta*, n = 24; *Cochlicella acuta*, n = 23; *C. ventrosa*, n = 23 and *Subulina octona*, n = 31.

INTRODUCTION

All the land snails which have been introduced into South Australia occur naturally in countries bordering the Mediterranean, some extending to Northern Europe and the British Isles. It is likely (Quick, 1953) that even those of wider distribution were introduced from the Mediterranean parts of their ranges; all flourish in the Mediterranean climate of the southern parts of South Australia. Eight species of Helicidae and one of the Ferussaciidae are known to occur in the State. The introduced Helicids are capable of prolonged aestivation which has no doubt aided in their distribution by man.

In his 1954 Catalogue of Introduced Snails and Slugs, Cotton records no species for the Northern Territory. At least two, *Subulina octona* (Brugière) and *Lamellaxis gracilis* (Hutton), belonging to the Subulinidae, do now occur there. *S. octona* certainly occurs naturally in tropical America and *L. gracilis* probably originated there also (Pilsbry, 1946).

Among the South Australian Helicidae only *Helicella caperata* (Montagu) which occurs naturally from Bagdad to the British Isles, was not available for cytological study. The only non-helicid snail introduced into South Australia is a species of *Ferussacia*. It was originally recorded as *F. folliculus* (Gronovius) (Cotton, 1954) but Venmans (1957) suggests that it is not yet possible to make a definite specific identification. The population described by Cotton still flourishes at Linden Park, an Adelaide suburb. Efforts were made to obtain gonadal material from this *Ferussacia* but no satisfactory preparations could be obtained in spite of the fact that the snails were breeding freely. Of the two subulinid snails introduced into the Northern Territory, *Subulina octona* was available for cytological study.

MATERIALS AND METHODS

Eight species of introduced land snail were used in this study, seven belonging to the Family Helicidae and one to the Subulinidae.

The upper few whorls of each shell were removed and a small piece of ovotestis was taken with fine forceps. This was mounted in a drop of aceto-orcein, tapped gently to spread the tissue and then inverted on absorbent paper and squashed firmly with the thumb. Gentle warming on a hot plate intensified the staining, and while the slide was still warm the coverslip was ringed with vaseline for immediate observation. Chosen slides were later made permanent. Vaseline was removed by wiping with xylene and the slide was inverted in absolute alcohol until the coverslip dropped off. The coverslip was then replaced with a drop of Euparal.

Duplicate voucher specimens from each collection are in the South Australian Museum.

In all species, chromosomes were observed at diakinesis and prometaphase of meiosis in primary spermatocytes; for a few specimens, spermatogonial mitotic division were also studied.

RESULTS

Subulina octona (Bruguière)

Distribution: Tropical America.

Introduced: Africa, Ceylon, East Indies, Australia.

Collections Studied: S.A.M. D.14856 Katherine, N.T., March, 1964.

The sole collection of this species came from a shade house in a garden in Katherine. Despite its tropical origins, this species shows the ability for prolonged aestivation. Specimens from Katherine were maintained dry, in the laboratory, from March 1964 until October of the same year. This ability to aestivate has no doubt aided in the distribution of the species by man. The haploid chromosome number is 31 (plate 8, fig. F).

Helix aspersa (Müller)

Distribution: Europe, Mediterranean.

Introduced: North and South America, South Africa, New Zealand, Australia.

Collections Studied: S.A.M. D.14859 West of Finniss, S.A., August, 1963. S.A.M. D.14822 Adelaide University Grounds, S.A., May, 1963.

The chromosome number observed (n = 27, plate 8, fig. B) confirms previous counts made on European and British material (Perrot and Perrot, 1937; Perrot, 1938; Evans, 1960). A single specimen of abnormality *acuminata* in which the whorls are less tightly coiled (S.A.M. D.14858, Wallaroo, S.A., November, 1963) showed no abnormality of the chromosome complement.

Theba pisana (Müller)

Distribution: Europe, Mediterranean, North Africa, Britain (may be an introduction).

Introduced: North America, South Africa, Australia.

Collections Studied: S.A.M. D.14860 ¼ mile west of Corny Point Post Office, S.A., November, 1963. S.A.M. D.14815 Outer Harbour, S.A., December, 1962. S.A.M. D.14838 Port Willunga, S.A., August, 1963.

Specimens Destroyed in Dissection: Corny Point, S.A., August, 1963.

Almost all previous records of *Theba pisana* in South Australia were based on misidentification of *Helicella virgata*. Exceptions are Taylor (1928) and S.A.M. collection D.14866. *Theba pisana* is however, now known from localities as widely separated as Venus Bay, Port Lincoln, Edithburgh and the South-East of South Australia. Present

identification has been based on anatomical as well as conchological characters. Anatomically, *Theba* is very different from *Helicella*. *Theba pisana* itself has only two long mucous glands and in the Helicinae, to which *Theba* belongs, the right ocular retractor muscle passes between the vagina and penis and the spermathecal duct has a diverticulum. In the Helicellinae the ocular retractor passes to the left of both vagina and penis, there is no spermathecal diverticulum, and the mucous glands are shorter and more numerous and are once or twice divided.

In all collections n = 30 (plate 8, fig. A) and spermatogonial mitoses showed 2n = 60. This species shows considerable variation in banding pattern. Shells may be densely banded with entire or interrupted brown markings, or they may have no banding at all. A range of intermediates occurs. Individuals with different banding patterns are identical cytologically and the two extremes may occur in a single population. The banding pattern is no doubt genetically determined but it is of no taxonomic significance.

Cochlicella acuta (Müller)

Distribution: South-west Europe, Mediterranean, British Isles.

Introduced: Australia.

Collections Studied: The single collection was made at Pine Point, Yorke Peninsula, S.A., in August, 1963. All specimens were destroyed in dissection; they had the calcareous penial sheath and broader penis which are characteristic of *C. acuta* and distinguish it anatomically from *C. ventrosa*.

Perrot (1938) showed *Cochlicella acuta* to have 23 pairs of chromosomes. This count was confirmed by observations on the specimens of the Pine Point collection (plate 8, fig. G).

Cochlicella ventrosa (Ferussac)

Distribution: Mediterranean.

Introduced: South Africa, Bermuda, U.S.A., Australia.

Collections Studied: S.A.M. D.14819 Rosetta Head, S.A., May, 1963. S.A.M. D.14861 Hampstead Gardens, Adelaide, S.A., May, 1963.

Destroyed in Dissection: Outer Harbour, S.A., July, 1963.

As in the related *C. acuta, C. ventrosa* has n = 23 (plate 8, fig. H). Two varieties have been noted in South Australia (Cotton, 1954), *C. ventrosa bizona* Moquin-Tandon with banded shells and *C. ventrosa inflata* Moquin-Tandon which is unbanded. Both have identical chromosome complements and since both occur together in the Rosetta Head population it is unlikely that the banding pattern has any taxonomic significance.

Helicella neglecta (Draparnaud)

Distribution: Mediterranean, South France.

Introduced: British Isles, Australia.

Collections Studied: S.A.M. D.14857 ½ mile north of Brentwood, Yorke Peninsula, S.A., August, 1963.

Specimens Destroyed in Dissection: 10 miles south-west of Yorketown, S.A., August, 1963. Half mile east of Port Turton, S.A., August, 1963.

In all collections n = 24 (plate 8, fig. C) in primary spermatocyte division figures and in spermatogonial mitoses 2n = 48. *Helicella neglecta* shows varying degrees of banding but as in *Theba, H. virgata* and *Cochlicella ventrosa* the chromosome number was uniform throughout the collections studied.

Helicella virgata (da Costa)

Distribution: Europe, Mediterranean, British Isles.

Introduced: Australia.

Collections Studied: S.A.M. D. 14854 ¼ mile west of Corny Point Post Office, S.A., November, 1963. S.A.M. D.14855 Souttar Point, Yorke Peninsula, S.A., November, 1963. S.A.M. D.14816 Hallett's Cove, S.A., June, 1963. S.A.M. D.14821 Rosetta Head, S.A., June, 1963. S.A.M. D.14817 Glossop, S.A., June, 1963.

In all collections n = 26 (plate 8, fig. D). *Helicella virgata* shows a bewildering array of variation in shell size and banding pattern. Shells may range from 10.5 to 17.5 mm in diameter; they may be marked with entire brown bands which vary in number and position, the bands may be interrupted, or banding may be absent. There may be banded and unbanded individuals and also considerable variation

in the size of mature snails in a single population; this is shown very well in the Hallett's Cove collection. Chromosome number and form is constant throughout.

Helicella stolismena (Bourguignat)

Distribution: Spain, France.

Introduced: Australia.

Collections Studied: S.A.M. D.14863 Murray Bridge, S.A., September, 1964.

In 1914 Gude described shells from Millicent as *Helicella mayeri* but they have since been found (Quick, 1953) to agree closely with *Helicella stolismena* (Bourguignat), although anatomical observations were necessary to verify the identification. The above collection of snails, conchologically identical to specimens from Millicent, has given anatomical evidence for identity with *H. stolismena*. The Murray Bridge snails have, on one side of the vagina, an outer larger dart sac with a dart and an inner smaller empty sac. In this they agree with *H. stolismena* so there is now little doubt that *H. mayeri* is in fact *H. stolismena* and is not close to *H. conspurcata* (Draparnaud) as Gude suggested.

Individuals from Murray Bridge have n = 26 (plate 8, fig. E).

Table I summarizes the chromosome numbers of the introduced species described above.

CONCLUSION

It has been stated (Burch and Heard, 1962) that chromosome numbers tend to remain constant within systematic groups of euthyneuran snails. This may however apply to taxa at very different systematic levels. Chromosome number may be essentially stable in genera, families, or even in higher units. A great majority of snails which have so far been examined in the order Basommatophora (the Ancylidae excepted) have n = 18 (Burch, 1960; Burch *et al.*, 1964); the few exceptions have n = 16, 17 or 19 and some groups show polypoidy on the base number 18 (Burch, 1964). Similarly, all 15 species of the family Polygyridae examined by Husted and Burch (1946), representing three genera from two subfamilies, have n = 29. *Satsuma myomphala,* a member of the Camaenidae, has n = 29 (Inaba, 1959) as do nine Australian members of the same family including species of the genera *Meracomelon, Sinumelon, Hadra, Xanthomelon, Pleuroxia,* and *Chloritobadistes* (Laws, unpublished).

Some euthyneuran groups do however show little stability of chromosome number. In the Succineidae n = 17, 18, 20, 21 and 22 are known for six species (Perrot, 1938; Inaba, 1959; Koyama, 1955; Laws, unpublished). Similarly, the Helicidae show a range of chromosome number (Perrot, 1938). In the seven helicids described above n = 23, 24, 26, 27 and 30 occur. The total range now known for the family is n = 21 to 30 with the exception so far of n = 28. Even within helicid genera, chromosome number may vary. It is constant for those species of *Helix* which have been studied cytologically, n = 27, but in *Cepea* n = 22 and n = 25 are known (Perrot, 1938) and in *Helicella* the present study has shown variation in number; Perrot (1938) found *H. obvia* to have n = 26; *H. virgata* and *H. stolismena* also have this number but in *H. neglecta* n = 24.

As yet, *Subulina octona,* is the only member of the super-family Achatinacea to be studied cytologically. Its chromosome number, n = 31, is among the higher ones recorded for the suborder Sigmurethra to which all snails of the present study belong; only the slug families Testacellidae and Limacidae have members with numbers exceeding n = 31. The Sigmurethra, considered to be the most advanced basommatophoran suborder, show higher chromosome numbers than the three more primitive suborders (Burch and Heard, 1962). n = 31 for *S. octona* adds another high chromosome number to those recorded for the Sigmurethra, further supporting the view of Burch and Heard that, in snails, increase in chromosome number tends to accompany phylogenetic development.

TABLE I

Chromosome Numbers of Introduced Lands Snails.

	Species	n	2n
Superfamily Achatinacea			
Family Subulinidae	*Subulina octona*	31	
Superfamily Helicacea			
Family Helicidae			
Subfamily Helicinae	*Helix aspersa*	27	
	Theba pisana	30	60
Subfamily Helicellinae	*Helicella virgata*	26	
	Helicella stolismena	26	
	Helicella neglecta	24	48
	Cochlicella acuta	23	
	Cochlicella ventrosa	23	

EXPLANATION OF PLATE 8

PLATE 8

Meiotic chromosomes of introduced land snails: chromosomes at diakinesis of spermatogenesis.

Fig. A. *Theba pisana.*
Fig. B. *Helix aspersa.*
Fig. C. *Helicella neglecta.*
Fig. D. *Helicella virgata.*
Fig. E. *Helicella stolismena.*
Fig. F. *Subulina octona.*
Fig. G. *Cochlicella acuta.*
Fig. H. *Cochlicella ventrosa.*

All drawings were made with the aid of a camera lucida.

ACKNOWLEDGMENT

The author gratefully acknowledges the help of a number of people; Mr. D. Pomeroy of the University of Adelaide, Mrs. M. Kenny and Mr. P. Aitken of the South Australian Museum, Mr. W. G. Buick of Adelaide and Mr. A. J. Turner of Katherine, N.T., have assisted in the study by collecting living snails.

REFERENCES

Burch, J. B., 1960: Chromosome studies of aquatic pulmonate snails. Nucleus 3: 177-208.

——— 1964: Cytological Studies of Planorbidae (Gastropoda: Basommatophora). I. The African subgenus *Bulinus* s.s. Malacologia 1: 387-400.

Burch, J. B. and Heard, W. H., 1962: Chromosome numbers of two species of *Vallonia* (Mollusca, Stylommatophora, Orthurethra). Acta biol. Acad. Sci. Hung. 12: 305-312.

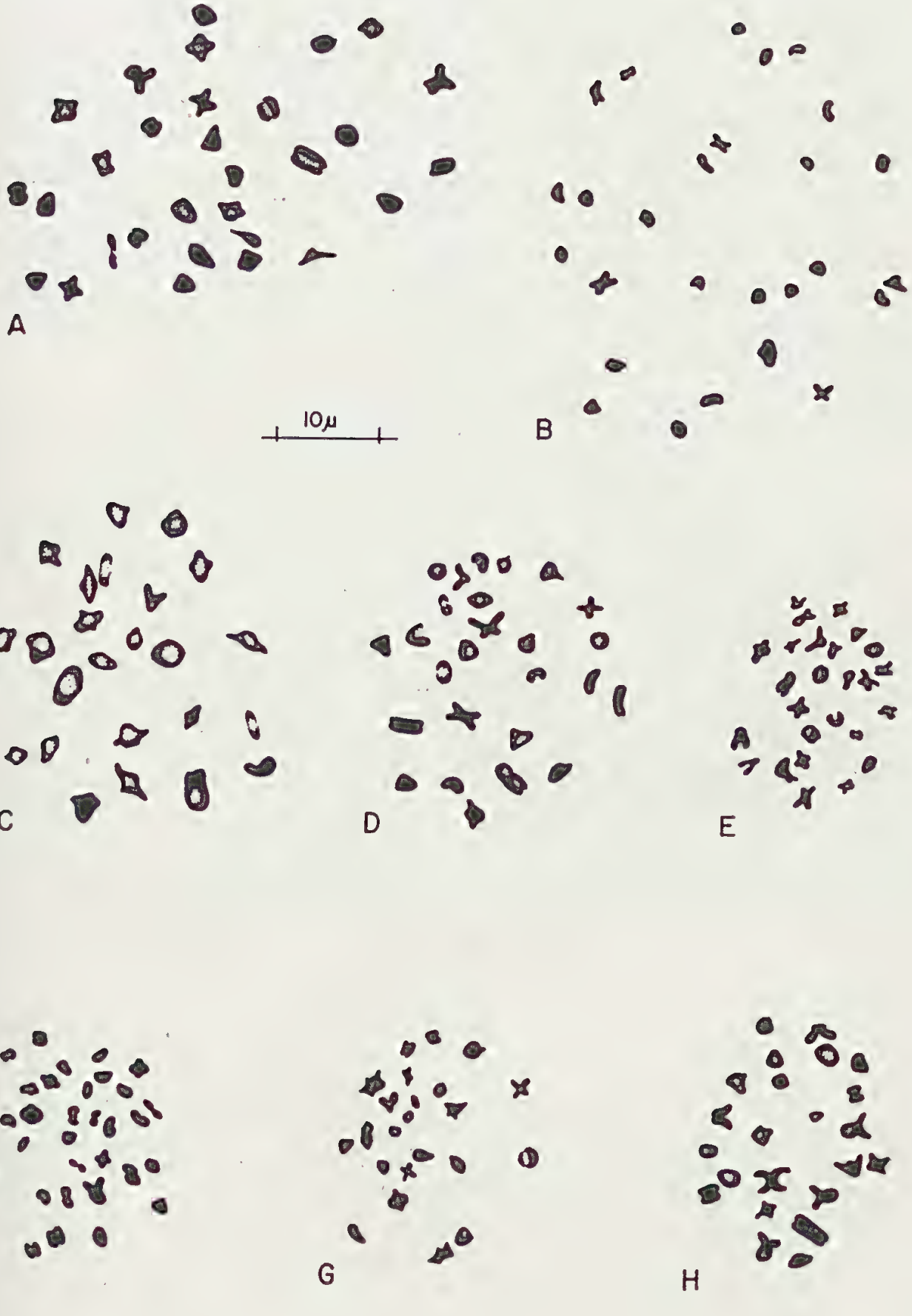
Burch, J. B., Williams, J. E., Hishinuma, Y. and Natarajan, R., 1964: Chromosomes of some Japanese freshwater snails (Basommatophora: Branchiopulmonata). Malacologia 1: 403-415.

Cotton, B. C., 1954: A catalogue of introduced snails and slugs in Australia. Rec. S. Aust. Mus. 11: 177-187.

Evans, H. J., 1960: Supernumerary chromosomes in wild populations of the Snail *Helix pomatia* L. Heredity 15: 129-138.

Gude, G. K., 1914: Description of a new Helicoid from South Australia. Proc. malac. Soc. Lond. 11: 166-167.

Husted, L. and Burch, P. R., 1946: The chromosomes of polygyrid snails. Amer. Nat. 80: 410-429.


A
10μ
B
C
D
E
F
G
H

Inaba, A., 1959: Cytological studies in Molluscs. II. A chromosome survey in the stylommatophoric Pulmonata. J. Sci. Hiroshima Univ., Ser. B, Div. 1. 18: 71-93.

Koyama, T., 1955: Studies on the chromosome numbers of two species of *Succinea* in Japan. Venus, Kyoto 18: 259-264.

Perrot, M., 1938: Etude de Cytologie comparée chez les Gastéropodes Pulmonés. Rev. suisse Zool. 45: 487-566.

Perrot, J. L. and Perrot M., 1937: La formule chromosomique de l' *Helix pomatia*. Rev. suisse Zool. 44: 203-209.

Pilsbry, H. A., 1946: Land Mollusca of North America (North of Mexico). Vol. II, Part I. Acad. Nat. Sci. Philad. Monograph No. 3.

Quick, H. E., 1953: Helicellids introduced into Australia. Proc. malac. Soc. Lond. 30: 74-79.

Taylor, J. W., 1928: *Helix pisana* (Müll.) in South Australia. Journ. Conch. 18: 208.

Venmans, L. A. W. C., 1957: A species of *Ferussacia* in South Australia. J. malac. Soc. Aust. 1: 36-44.

ZUSAMMENFASSUNG

Die Chromosomenzahlen, in primären Spermatocyten, für sieben in Süd Australien eingeführten Arten von Schnecken (Helicacea, Helicidae), sind: *Helix aspersa*, n = 27; *Theba pisana*, n = 30; *Helicella virgata* und *H. stolismena*, n = 26; *Helicella neglecta*, n = 24; *Cochlicella acuta* und *C. ventrosa*, n = 23. *Subulina octona* (Achatinacea, Subulinidae), eine Art die in das Nord-Territor eingeführt worden ist, hat n = 31.

ABORIGINAL ROCK POUNDINGS ON GALLERY HILL, NORTH-WESTERN AUSTRALIA

By CHARLES P. MOUNTFORD, Honorary Associate in Ethnology, South Australian Museum

Plate 9 and text fig. 1-8

CONTENTS

Introduction.
(1) Techniques used in producing rock poundings.
(2) Methods of recording.
(3) Distribution of petroglyphs.
(4) Description of rock poundings.
(5) Sequence of rock poundings.
(6) Origins and meanings.
(7) Summary.
Acknowledgments.
Bibliography.

INTRODUCTION

This paper records an extensive group of rock poundings at Gallery Hill about 200 miles in a south south-easterly direction from Port Hedland, and 20 miles from the Abydos research station (map, fig. 1).

This hill, first named and investigated by the Reverend Father Worms (1954, pp. 1067-88), is a huge pile of granite boulders, which, according to their discoverer, is 930 feet long, 300 feet wide and 200 feet high. The base is somewhat oval in form with the major axis lying in a north-south direction.

Gallery Hill, which rises directly out of a level plain, is only one of a number of similar geological features in the surrounding country. There are a few rock poundings on adjacent hills examined by the author, but none of these have such a profusion of designs on their surfaces as Gallery Hill.

Previous research on the rock art in other parts of Australia has shown that the widely distributed pecked engravings are, almost without exception, situated near some form of water supply; a watercourse, rockhole or spring (Mountford 1928, p. 342).

Although, at the present time, there is no evidence of a water catchment in or near Gallery Hill, it is possible that one existed, probably on the northern end, before the aborigines left this area to work for the white man. If this catchment had not been cleaned out continuously it would soon fill with sand and debris and all memory of it be lost. This has already happened to a large number of aboriginal rockholes, soaks and springs throughout Australia.

The second possible reason for the concentration of rock poundings at Gallery Hill is that it may once have been an important centre where, at certain times of the year, the aborigines assembled to perform the associated totemic rituals and, perhaps, at the same time, pound designs on the rocks relating to their beliefs.

These suggestions however are hypothetical; at present there is no direct evidence to show why there are so many rock poundings on Gallery Hill and so few on the hills examined in the adjacent country.

(1) *Techniques used in producing rock poundings.*

The rock markings at Gallery Hill and Wamarana (Worms, 1954, pp. 1067-88); Sherlock Hill (Mountford, 1964, in press); Depuch Island (McCarthy, 1961, pp. 121-48); Petri and Schultz, 1951, pp. 70-93), and those recorded by Davidson (1952, pp. 76-117), are produced by a different technique from that of the pecked engravings so widespread throughout Australia. Engravings of the latter type, many of which are of great age[1] consist of a series of indentations or gashes in the rock surface, probably made by a sharp-edged boulder held in the hand[2]. Plate 9D is an example of rock engravings from Rock Cod Island in the Port Hedland area.

(1) Mountford (1929, pp. 243-248), records a rock engraving from Panaramitee North in South Australia that bears a strong resemblance to that of a sea-going crocodile. The present habitat of this creature is now over 1,000 miles north. Later, Mountford and Edwards (1962, p. 172), published a description of a marine turtle and a fish from the same area. The present coastline is over 100 miles from these engravings.

(2) Throughout this paper I have used the general term petroglyphs for all types of rock markings; reserving the term engravings for those examples where the designs consist of a series of punctures or indentations (pl. 9D); and poundings where the designs, as on Gallery Hill and Depuch Island, have been made by battering the rock surface (pl. 9A, B, C).

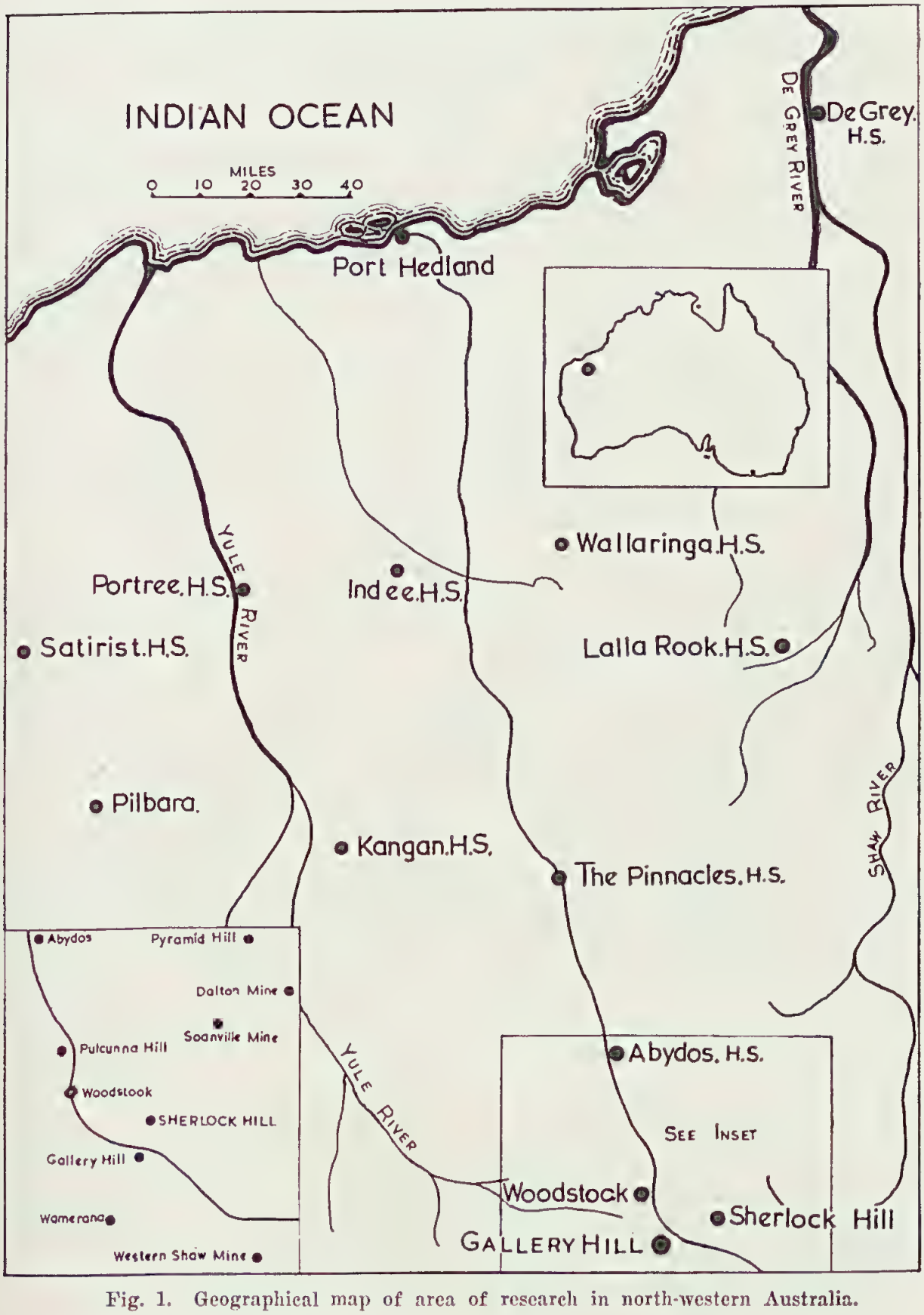


Fig. 1. Geographical map of area of research in north-western Australia.

On the other hand, the rock poundings on Gallery Hill are the result of battering the surface of the rock with a rounded stone until the dark-coloured patina is destroyed, leaving a white mark the shape of the design (plate 9A).

Withnell (1901, p. 29), describes a technique of rock pounding employed by the aborigines in the Roebourne area which is, almost certainly, the same as that used at Gallery Hill. He writes:

> 'They (the aborigines), have many rock carvings; every hill that has suitably hard stone will have some kind of figure tattooed thereon. They do not choose the softer rocks, and mainly prefer basalt and granite. The method adopted is to draw the outline with chalk or ochre and with a hard stone hammer within the outline until the rock is fretted away about an eighth of an inch deep . . .'

Clements (1903, p. 9), also made a short reference to the same subject.

The rock poundings on Depuch Island described as rock engravings by Wickham (1842, pp. 79-83), and later by McCarthy (1961, pp. 121-48) and others, have recently been examined and photographed in detail by the author.

A close examination of these designs showed that they, like the rock poundings on Gallery Hill, had been made by battering the basaltic rocks of Depuch Island with a sharp-edged stone until the surface was eroded to the shape of the required design.

The fact that the aborigines at Depuch Island used sharp-edged stones and those at Gallery Hill, Roebourne and in Central Australia (mentioned later) only rounded boulders was, no doubt, determined by the type of material available. Whichever type of abrading tool was employed however, the final results were comparatively shallow markings of similar appearance. A comparison of the photographs of rock poundings at Gallery Hill and Depuch Island (plate 9 A, B, C), with a rock engraving at Rock Cod Island in the Port Hedland area (plate 9 D), illustrates the wide difference between the two types of petroglyphs.

Rock pounding, the same technique as that probably used by the aboriginal artists at Gallery Hill, is still a living art over a wide area in central Australia (fig. 2) where the author has photographed and later recorded the aborigines producing their rock pictures by battering or pounding the rock surfaces (Mountford, 1955, pp. 345-52).

By using the same method of rock pounding I have been able to produce designs on the boulders of Gallery Hill which were, to all intents and purposes, indistinguishable from those made by the aborigines. It was necessary however, to use larger boulders and strike heavier blows to break through the patina on the granite boulders at Gallery Hill than it was on the rocks of central Australia where, apparently, the surface is much less resistant to erosion. On Depuch Island, too, comparatively light blows with small sharp-edged stones, broke through the patina on the basaltic rock.[3]

(2) *Methods of Recording.*

To record the rock poundings on Gallery Hill an eye-level camera and colour film was used, care being taken that, as near as possible, all exposures were made at right angles to the rock face on which the design had been pounded. An Australian florin was included as a scale, on most, but not all of the photographs. This is the reason why the scales on figs. 4-6, 8, are shown as approximate.

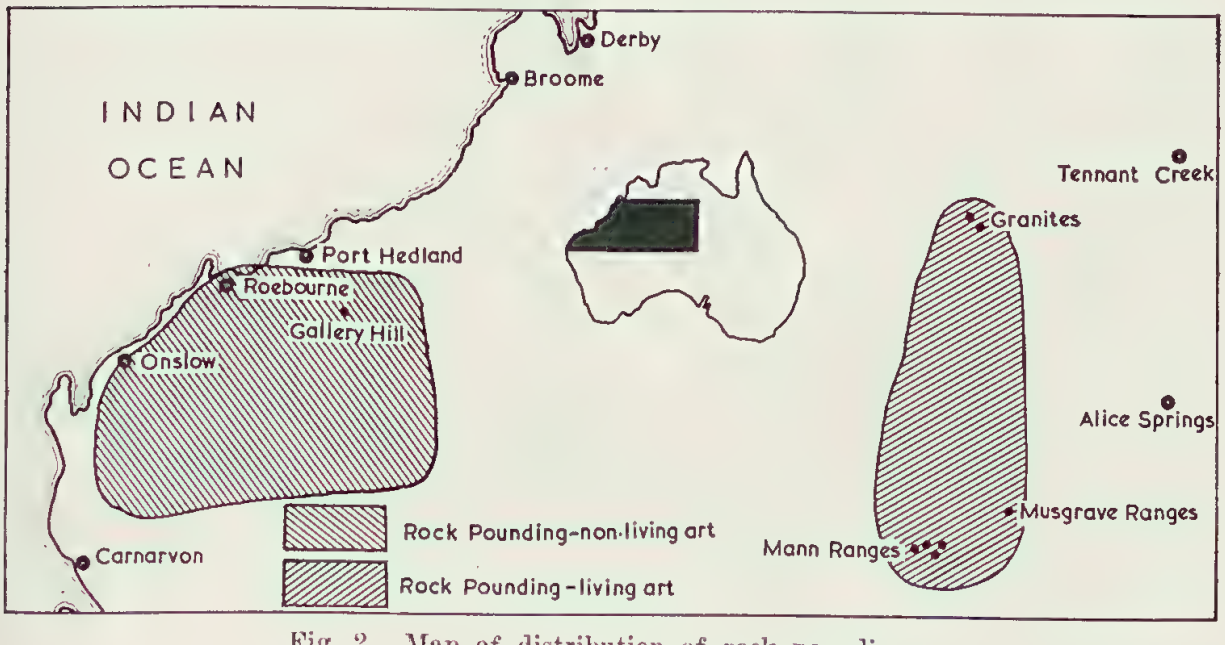


Fig. 2. Map of distribution of rock poundings.

To prepare the illustrations for publication a black and white photograph was first made from each colour transparency, and the florin, when it was included, enlarged to the same size in all prints.

(3) Since going to press, Mr. Ian Crawford (1964), has published an excellent and accurate description of the rock engravings of Depuch Island. The rock markings illustrated by Crawford would fall in with my description of rock poundings.

The image of the rock pounding was then inked in, with continuous reference to the colour transparency, and the photograph bleached. The resultant drawing was then mounted with the others to make up the text figures.

By using these techniques it was possible to obtain a far more accurate representation of the rock poundings on Gallery Hill than by any other method.

(3) *Distribution of petroglyphs.*

An examination of Davidson's map (1952, p. 77), shows that there is not only fully identified petroglyphic site south of an east-west line drawn from Carnarvon, on the west coast of Western Australia. Nor is it certain, with any degree of accuracy, that petroglyphs have been found north of the southern edge of the Great Sandy Desert.

Although Davidson's evidence on petroglyphs (much of which was obtained by personal interviews with local residents), is often indefinite, it has been possible to identify from his illustrations five localities of rock poundings, *i.e.*, Mount Edgar and Parri Muccan, more or less on the southern edge of the Great Sandy Desert; Coopooey, in the Roebourne area and Williamsbury and Gifford Creek, in the country north-east of Carnarvon. Withnell (1901, p. 29) and Clements (1903, p. 9), record what were probably rock poundings from the Roebourne area and, Wickham (1842, pp. 79-83) and McCarthy (1961, pp. 121-48), from Depuch Island. Mountford (1964, pp.) has recorded rock poundings from Sherlock Hill, and Worms (1954, pp. 1067-82), from Gallery Hill.

The distribution map, fig. 2, based on the research of the above authors, from information gathered from local residents, and my additional investigations suggests that all the petroglyphic sites in Western Australia, north of Carnarvon and south of the Great Sandy Desert [with the exception of the rock engravings in the Port Hedland area recorded by McCarthy (1962, pp. 1-74), and others] can be classified as rock poundings.

Included on the same map are localities of the living art of rock pounding found in central Australia (Mountford, 1955, pp. 345-52). Examples of this living art extend from the Granites gold field, in north-western central Australia, to the end of the Mann Range on the border of central and Western Australia. There is no doubt that future research will reveal many additional sites in this area.

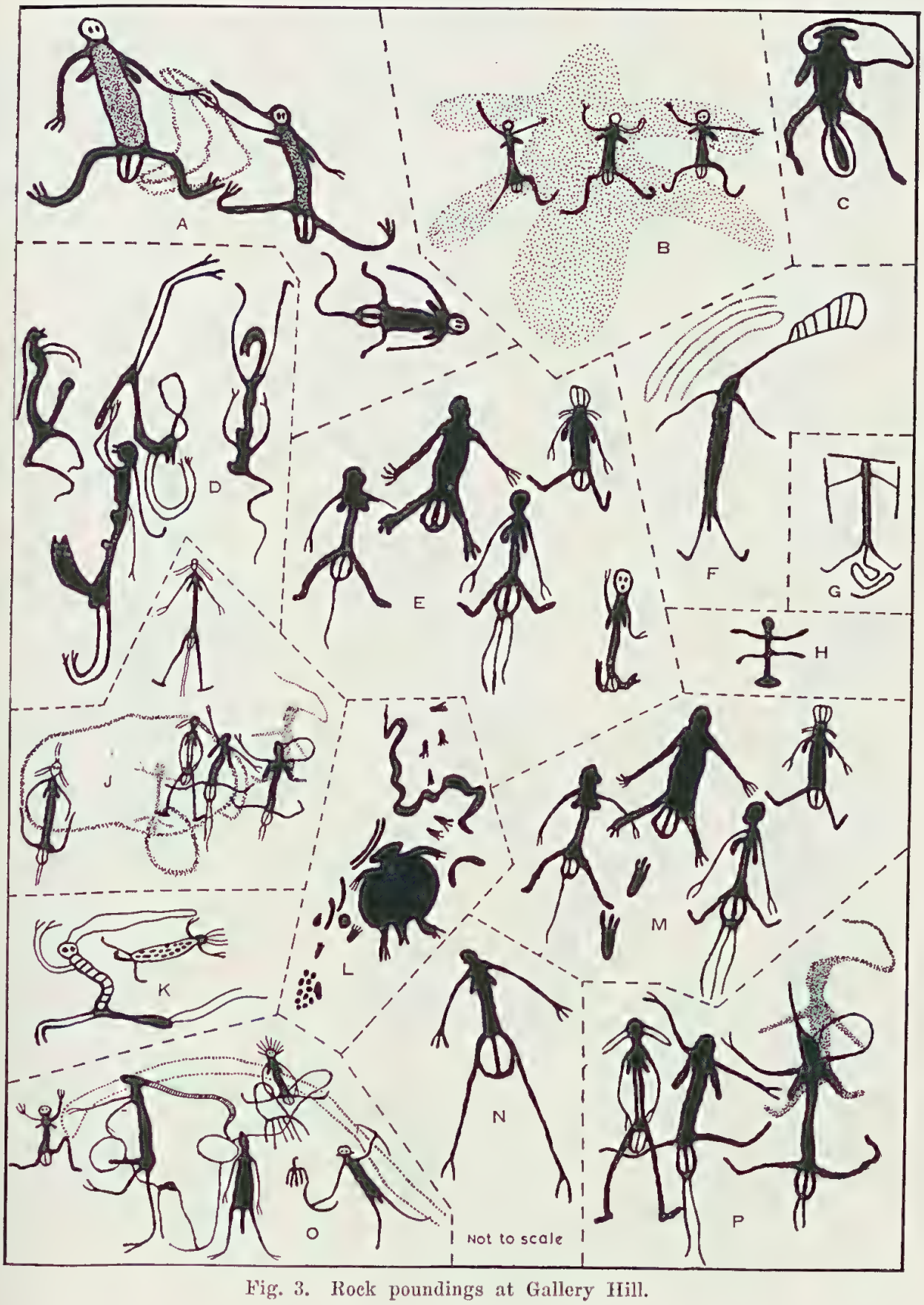


Fig. 3. Rock poundings at Gallery Hill.

As, according to Davidson (1952, p. 112), what is probably the same type of rock pounding extends eastwards to Opthalmia Range Gap on the upper reaches of the Fortescue River in Western Australia, and only 600 miles of almost unknown country separates it from the living art of central Australia, it is more than likely that future research will link the eastern and western areas. Such a link, coupled with Withnell's and Clement's evidence that rock pounding was a living art at Roebourne within this century, would suggest that the rock poundings at Gallery Hill have been made during comparatively recent times.

(4) *Description of Rock Poundings.*

As the rock poundings on Gallery Hill are numerous, only a limited number are illustrated on figs. 3-8. This selection however may be taken as representative of the whole series.

(*a*) Complex designs of men and women with exaggerated genitalia.

(*b*) Simpler representations of men and women.

(*c*) Simple designs, in which figures of human beings are reduced to a series of lines.

(*d*) Curvilinear abstract patterns without any obvious meaning.

(*e*) Creatures.

(*a*) These decorative rock poundings of men and women are more numerous at Gallery Hill than any other design. In general the men have exaggerated penes, such as figs. 3D, K and O; 4A, B, H, J, and M; 5B, G, J, L, N, O and Q; 6D, K; and 7B. The women, too, are shown with much enlarged vulvae having, in a number of examples, lines leading from them. Examples are figs. 3E, J, M, and P; 4P; and 6C[4]. Some of my informants considered that these lines represented urine, and others, menstrual fluid.

Almost without exception, the rock poundings in group (*a*) showed men and women in strong action, often in the most decorative positions. They usually have long thin limbs and, in most examples, only two fingers on each hand, although some have three or more. A number of these figures are also wearing attractive head-dresses.[5]

(4) Withnell (1901, p. 29) and Clements (1903, p. 9), refer to the rock markings at Roebourne as depicting men and women in vulgar attitudes. This appears to be a characteristic of the rock poundings of north-western Australia.

(5) Worms (1954, p. 1075, figs. A, B) illustrates a number of these head-dresses. He links some of these with the *gurangara*—I do not feel this is proven.

Fig. 4. Rock poundings at Gallery Hill.

(*b*) Throughout the rock poundings on Gallery Hill are a number of more or less static figures of men and women, usually without highly exaggerated genitalia and head-dresses. Some are illustrated on figs. 3L; 4K; 5K; and 6A, U. Worms (1954, p. 1073) who also refers to some of these markings, considers that they are older than group (*a*).

(*c*) This group consists of a number of much simplified representations of human beings skilfully reduced to a series of lines. Fig. 3G represents a man wearing what is probably the ceremonial engraved head ornament, *tini,* and holding a stick or a shield in either hand. His penis has been extended to form a meandering pattern. Fig. 3H, probably depicts a man with a large penis. Fig. 5E is a particularly simple rock pounding. Nevertheless it is possible to recognize a man with a long penis wearing a head-dress and carrying a boomerang in one hand. Figs. 6G and H are two more simple figures. The first, with two fingers on each hand, is made up entirely of a circle for a head and narrow single lines for the limbs and body; the second (fig. 6H), with a head-dress of radiating lines, is carrying a weapon in one hand. Fig. 7A depicts an armless individual, with the legs turned sharply upwards, wearing a long head-dress. Fig. 8L, a much simplified design, almost certainly illustrates a long-legged human being. The upper curving lines represents a head-dress, and the two lower lines, the arms.

There are a few examples of over-carving among the rock poundings on the northern side of Gallery Hill. Wherever this has happened, the older figures are indicated in the illustrations by a series of dots. Most of the more ancient human figures (figs. 3J, P and 4E) are wearing a form of head-dress that is not present on any of the figures in full line. It is possible that these rock poundings are examples of an earlier phase of the art of Gallery Hill. On the other hand, the design of a partly defaced man carrying a boomerang in either hand (fig. 6C) is almost identical with another in full line (fig. 4L).

(*d*) The simplest and, without doubt, the most ancient forms of rock pictures on Gallery Hill (fig. 8) were found sparsely scattered around the base and on the eastern end.

In general these poundings consist of abstract circular and curvilinear patterns. There are, however, two linear designs (fig. 8A and N), the former of which may be either an elaborated human figure or a lizard, and the latter, perhaps, a series of emu tracks.

Fig. 5. Rock poundings at Gallery Hill.

(*e*) The rock poundings depicting creatures form a small proportion of the engravings. There is a curious bird-like figure, wearing a long head-dress at 6P;[6] two kangaroos at 6R, T; a bandicoot-like creature at 6Q; a probable freshwater crab at 6S and a curious unidentified creature at 6M. There is a snake at 3L, a non-human figure under the three women at 3B, and what may be a grub-like creature at 5M. The three dotted figures at 7B are of some interest. On the one hand they resemble a fresh-water turtle, which is present in the rivers and, on the other, some sting-ray like creature which belongs to the sea.

(5) *Sequence of rock poundings*

As mentioned earlier, Gallery Hill is a large oval pile of boulders with the major axis lying in a north-south direction. The most complex rock poundings (figs. 3, 4, 5, 6, 7), are grouped exclusively on the north-easterly, northerly and north-westerly sides, and the simple abstract patterns (fig. 8) scattered sparsely all around the base of the hill. On the northern side many of these simple designs (shown as a series of dots) are partly obscured by more complex figures, *i.e.*, figs. 3A, B, F, J, O, P and 5Q. These simple poundings are the only ones present on the southern end.

The more complex poundings, being lighter in colour, stand out clearly against the dark-coloured rock (plate 1A) but the simpler forms, being patinated to a greater or lesser degree, are much darker in colour.

At present, three sequences of these simple figures can be recognized; the abstract patterns shown on fig. 8, and those partly covered by fig. 3A, B, F and O, and 5Q; a more advanced type under the more complex figures at figs, 3J, P; 4E; 6C; and fig. 7B. Worms (1954, p. 1073), considers that my fig. 6A belongs to an earlier phase. A detailed analysis of the markings on a number of sites within the same area will probably establish a number of definite sequences.

(6) *Origin and meanings.*

There is a tendency on the part of some investigators to accept the statements of aborigines as absolute fact, whereas they may have no specific knowledge, but merely be expressing an opinion. This has happened to me both at Gallery Hill and, many years earlier, at Red Gorge in South Australia (Mountford and Edwards, 1965, in press).

(6) Worms (1954, p. 1074) considers that this design represents a man. This may be so.

Fig. 6. Rock poundings at Gallery Hill.

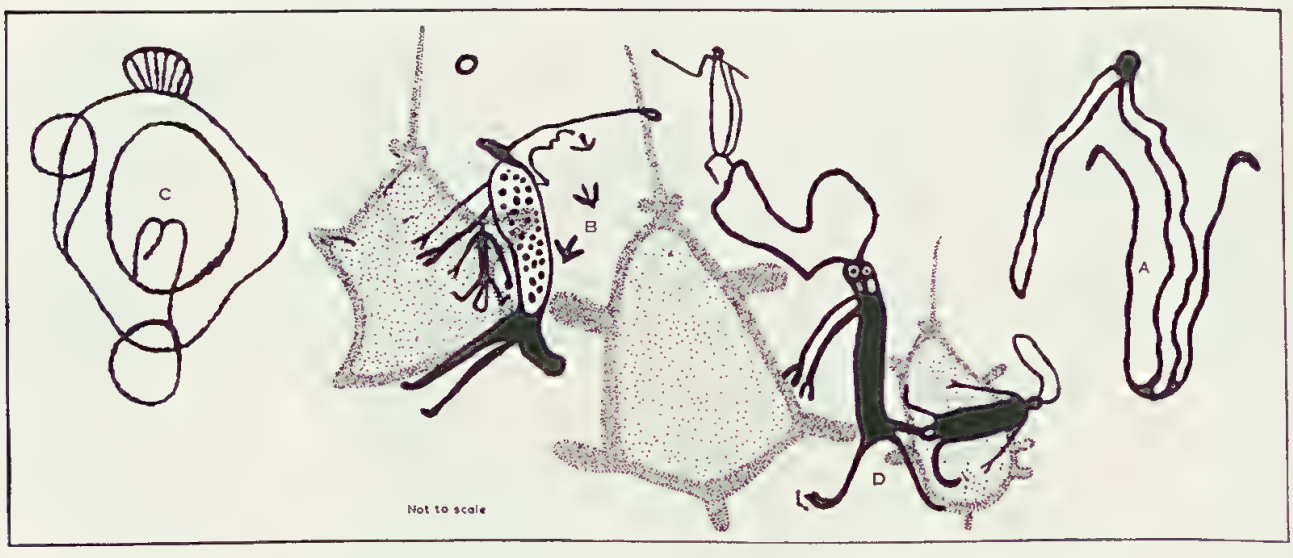


Fig. 7. Rock poundings at Gallery Hill.

When I asked the local aborigines about the origin of the rock pictures at Gallery Hill, I was told that they had been made by the *Minjiburu,* a group of mythical women whom the aborigines believe had created most of the topographical features in the surrounding country.

Later, one of the old men, in conversation, said to me:

> 'Them fellows say *Minjiburu* women made those marks but they're only guessing. We blackfellows don't know who made them; we only think it was the *Minjiburu.*'

To find out whether there was any reference to rock poundings in the *Minjiburu* myths I recorded a long series of chants describing the travels of these women. The results were entirely negative.

Worms (1954, p. 1082) considers that the most recent layer of poundings on Gallery Hill are connected with the *gurangara* cult which, according to him, moved into the area from the east during historical times. He bases his assumption that according to him, as the *gurangara* ceremonies terminate in ritual coitus, and that as a number of the rock poundings at Gallery Hill show men and women in that act, those rituals and the rock poundings are associated.

An examination of Worm's illustrations (plate 1c, d; 2d; and 3a, b), shows that he has based his hypothesis on faulty information. He quotes his illustrations as—

> '. . . engraved men and women in circumstances connected with the sexual act . . . I am of the opinion that these coitus

> engravings are early reflections of the *gurangara*. That is the reason I have called them the *gurangara* petroplyphs.'

Yet plate 1c, d is, according to his caption, a 'Frieze of men', (see my fig. 3D) and his plate 2d, a woman and a dim figure of a man some distance apart. In his plate 3a, the figures are not copulating, although they may be preparing to do so (see my fig. 4H), and his plate 3b is a male figure and what may be a female, but they are certainly not copulating. This examination of Worm's illustrations shows the hypothesis that the *gurangara* cult and the rock poundings at Gallery Hill are associated is based on a single uncertain design (*i.e.*, my fig. 4H) depicting coitus.

Nevertheless, I did find a clear-cut illustration of coitus at Gallery Hill (fig. 7D), and McCarthy (1961, p. 27) has illustrated a number of men and women at Depuch Island in the act of coitus.

Because of the conflicting and somewhat indefinite evidence it would not be safe at present to assume that the rock poundings at Gallery Hill, Sherlock Hill or Depuch Island are linked with either the myth of the *Minjiburu* women or the *gurangara* cult. But, on the other hand, it would be equally unwise to deny categorically that it was not so until much more information is available.

The vitality, beauty and wide range of designs at Gallery Hill, Sherlock Hill and Depuch Island, and at other localities in the rock pounding area of north-western Australia, suggests that some new and powerful cultural influence must have stimulated the aborigines to develop a petroglyphic art form that is more varied and decorative than elsewhere in Australia.

The fact that the present-day aborigines have lost all memory of the origin of these rock markings does not indicate great age. Both Stanner (1956, p. 52) and Mountford (1965, p. 24) show that the aborigines, having no history in our sense of the word, quickly discard all knowledge of past events.

(7) *Summary*

The petroglyphic art of Australia consists of two forms, the rock engravings and the rock poundings.

Rock engravings, widespread throughout Australia, are made up of a number of closely-spaced indentations or punctures in the rock surface, that have been cut with a sharp-edge stone tool. It has been shown that many of these engravings are of great age.

Fig. 8. Rock poundings at Gallery Hill.

Rock poundings, on the other hand, are produced by battering the surface of the rock with a boulder until the dark-brown patina is destroyed, leaving the design as a white mark. This technique is a living art in central Australia.

There is a wide range of pounded designs on the rocks of Gallery Hill. The most numerous of them are the decorative and vital rock pictures of men and women often with exaggerated genitalia and headdresses of many designs. There are also static figures of human beings, simple pictures of men and women made up of remarkably few lines; abstract curvilinear rock poundings and a few representations of the creatures.

Our present knowledge of the petroglyphic art of north-western Australia suggests that the rock engravings are confined to the coastal regions adjacent to Port Hedland, and that the art of rock pounding extends to the south and east of that locality.

It is possible that future research will link the living art of rock pounding in central Australia with that of north-western Australia.

ACKNOWLEDGMENTS

My thanks are due to the Wenner-Gren Foundation of New York, to the Australian Institute of Aboriginal Studies and the Social Science Research Council for the funds that made it possible for me to carry out the research in this and other units of aboriginal art in north-west Australia. I am also grateful to Mr. Reginald Sherlock, both for his hospitality and his kindness in transporting my party to the rock pounding site at Gallery Hill; to Mr. E. Roberts, District Officer of Native Welfare for his kindness and assistance; to the Director of the South Australian Museum for the use of his facilities; to the Principal Librarian of the Public Library of South Australia for photographic supplies and the assistance of his staff; to Miss Brenda Hubbard for many of the tracings and to Miss Margaret King for her help both in the field and her assistance in the preparation of this paper.

REFERENCES

Clements, E., 1903: Ethnographic Notes of the Western Australian Aborigines. Int. Arch. Ethnogr. Leiden, 16.

Crawford, I., 1964: Report on the Aboriginal Rock Engravings . . . of Depuch Island, Western Australia. Spec. Publ. No. 2, W. Aust. Mus.

Davidson, D. S., 1952: Notes on the Pictographs and Petroglyphs of Western Australia and a discussion of their affinities with the appearances elsewhere on the Continent. Proc. Amer. phil. Soc. Philadelphia, 96, 1.

McCarthy, F. D., 1961: The Rock Engravings of Depuch Island. Rec. Aust. Mus. Sydney, 25, 8.

——— 1962: Rock Engravings at Port Hedland, North-Western Australia. Kroeber Anthrop. Soc. San Francisco, 26.

Mountford, C. P., 1928: Aboriginal Rock Carvings in South Australia. Rep. Aust. Ass. Advanc. Sci., Hobart, 19.

——— 1929: Unique Example of Aboriginal Rock Carving at Panaramitee North. Trans. Roy. Soc. S. Aust. 53.

——— 1955: An unrecorded Method of Aboriginal Rock Markings. Rec. S. Aust. Mus. 11(4).

——— 1965: Ayers Rock, its People, their Beliefs and their Art. Sydney.

——— 1965: Rock Poundings on Sherlock Hill, Abydos Station, N.W. Aust. Antiquity Cambridge (in press).

Mountford, C. P. and Edwards, R., 1962: Aboriginal Rock Engravings of Extinct Creatures in South Australia. Man, London, 62, Article 174.

——— 1965: Rock Engravings in the Red Gorge, Deception Creek, Northern South Australia. Anthropos, St. Augustin 1965 (in press).

Petri, H. E. and Schultz, A. S., 1951: Felsgravierungen aus Nord-west Australien. Zeitscrift fur Ethnologie, Berlin, 76(1).

EXPLANATION OF PLATE 9

PLATE 9. ABORIGINAL PETROGLYPHS.

A. Rock poundings, Gallery Hill.
B. Close-up of rock poundings, Gallery Hill.
C. Rock poundings, Depuch Island.
D. Rock engravings, Rock Cod Island, Port Hedland.

A

B

C

D

Stanner, W. H. E., 1956: The Dreaming. The Australian Signpost, Sydney.

Wickham, Capt., 1842: Notes on Depuch Island. Journal of Royal Geographic Society, London, 12.

Withnell, John G., 1901: The Customs and Traditions of the Aboriginal Natives of North Western Australia, Roebourne.

Worms, E. A., 1954: Prehistoric Petroglyphs of the Upper Yule River, North-western Australia. Anthropos, St. Augustin (49).

RESUME

L'art pétroglyphique de l'Australie se compose de deux formes—les gravures en pierre, et les fondus en pierre.

Les gravures de pierre, agées de bien des années, consistent en quelques impressions serrées dans la surface, faites par un outil affile en pierre.

On produit les fondus de pierre en battant la surface jusqu'à la destruction de patina, ce qui laisse le dessin comme une marque blanche.

Ce journal discute les techniques de production, la distribution, les origines, les significations et la succession des fondus de pierre que l'on trouve à Gallery Hill, du nord-ouest de l'Australie Ouest. Ceci decristet en détail les dessins que l'on y trouve.

FISHING RITES AT BE-MALAI, PORTUGUESE TIMOR

By MARGARET J. E. KING

Plates 10-11 and text fig. 1

CONTENTS

Introduction and geographic detail.
(*a*) The myth.
(*b*) The rites.
(*c*) Description of ceremony.
(*d*) Economic aspects of the fishing ceremony.
(*e*) Function of the ceremony.
Summary.
Acknowledgments.

Fig. 1. Area map and inset of region in Timor connected with the fishing rites of Be-Malai.

INTRODUCTION

This paper describes and illustrates the sacrificial rites and ceremonial fishing activities witnessed by the writer in August 1960 at the estuary of Be-Malai in central Timor. The region in which Be-Malai is situated is bounded on the north-west coast by the Ombai Strait and, landward to the south-east, by the confluence of the rivers Lois and Be-Bai. These rivers form the main hydrographic basin of Portuguese Timor. (Map. Fig. 1.)

A mountain chain runs parallel to the coast, the principal peaks of which are, Kotabot (518 m.), Saniran (759 m.) and Samono (729 m.) which lie to the south-west of the estuary. Ingerhitoe (464 m.) is situated on the coast to the north-east of Be-Malai, and the peak Atabai (991 m.) dominates the inland area to the west of the river Lois.

The area of Atabai is the home of one of the two groups of people taking part in the rituals to be described, their name being derived from the peak. The other clan—known as the men of Balibó, live in the flat inland region behind Kotabot and Saniran.

Along the coastal area of Be-Malai, bounded by Cape Fatue Sue on the north-east and, for 160 kms. in a south-westerly direction to the outlet of the river Be-Bai, the off-shore shows markedly more shallow than in the adjacent coastal areas. For some 32 kms. inland the country is equally flat. The abovementioned mountain chain rises abruptly from this level plain.

The area in which the festival of Be-Malai takes place is dominated by the mountain Samono. The salt-water tidal flats of the Be-Malai estuary teem with fish of excellent size and quality and exceptionally large prawns. The sea-going crocodile, also present in reasonably large numbers, is regarded by the peoples of Atabai and Balibó as a mythical ancestor.

The rites described in this paper, practised by the Timorese clans of Balibó and Atabai at Be-Malai, apparently of great antiquity, commemorate the myth of the creation of Be-Malai. (Be—water; Malai—foreign.) These rites take place every four years, usually on August 29th and 30th, but this date is governed by the appearance of dead or dying fish and prawns floating on the water. This the Timorese take as a sign that the power of the *Lulic* (supernatural influence) in the water is waning and requires rejuvenation. When I observed these ceremonies they had been advanced to August 19th and 20th for this reason. If the rains have been exceptionally heavy the festival is occasionally held within the four year period. How-

ever, according to my informants, this occurs but rarely and then only at the express command of the *Rai-lulic*[1] of Balibó after due discussion with the chieftains of Atabai and Balibó. These chieftains are responsible for the assembly of their people along the banks of the estuary, to recreate the myth and participate in the two days of continuous fishing which follows the successful conclusion of the sacrificial rites.

(*a*) *The Myth.*

There were once two great chieftains, one of Atabai and one of Balibó. (Map. Fig. 1.) Because there had been much dissension concerning the boundary lines between the two groups of peoples, they met to discuss the just division of areas within the region. The two men, unable to reach agreement, fell to fighting with their staves.

While the fight was in progress a very aged woman appeared, carrying on her head a large cooking-pot full of water. The chief from Balibó struck her on the head with his stave which broke in two as it smashed the pot which she was carrying. The old woman disappeared but the water from the broken pot flowed away to form the estuary of Be-Malai.

(*b*) *The Rites.*

In former times a man from Balibó, renowned for his physical strength, was killed as a part of the fertility sacrifice. I was told by a Portuguese official that this cult of human sacrifice was suppressed by the Portuguese, following the 1769 consolidation of their colonisation of Timor, which commenced in 1522.[2]

Before this time it was necessary for the man selected for sacrifice to belong to the family of the chief of Balibó. But, it would seem from the information gathered, that only rarely would an actual member of the *Rato* (highest social caste) be sacrificed for, unless it was obvious that a *Rato* was an outstanding physical specimen, a member of the *Patcha* (nobility ranking immediately below the *Rato*) would be chosen, and formally adopted as the son of the chief of

(1) *Rai-lulic.* A type of high priest of animist ceremonies. The *Rai-lulic* of each clan is elected for life and is the supreme authority on all matters of *lulic* pertaining to the daily life of the clan.

(2) Bearing in mind numerous reports of other substitution sacrificial rites throughout the world, and the fact that I was unable to obtain any precise information from alternative sources to confirm or deny this statement, suggests it may be a rationalization developed over a considerable period of time. It is doubtful that the edict against human sacrifice could have been successfully imposed on the Timorese prior to the complete pacification of the island by the Portuguese in 1913.

Balibó. While this conferred little advantage on the victim, it was of considerable benefit to his mother and her children who were older than the sacrificial victim (younger children did not receive a rise in status). The mother was presumed to have been a wife of the Chief and therefore, theoretically, her sons were in line to inherit the estates, and her daughters free to marry into neighbouring *Rato* families.[3] In practice this rarely occurred, for the 'sons' would be called upon to defend the honour of their 'father' upon numerous occasions (and often be killed in the process) and the daughters would be married off to their 'brothers'—the natural sons of the chief—thus ensuring that the 'sacred blood' was not mixed with any other ruling family or caste.

At the present time a black boar and a young female buffalo are sacrificed and the human victim offered symbolically. If the chief of Balibó has no son, the substitute is also only adopted symbolically into the *Rato* family and any elder children of his mother continue their *Patcha* status. The female buffalo comes from the herds of the chief of Balibó and he and members of his family are the first to partake of the flesh following the death of the sacrificial animal. The symbolical 'victim', although technically part of the family, does not receive any of this flesh. It is possible that the black boar also comes from the herds belonging to the chief of Balibó, but of this I have no direct information.

(*c*) *Description of ceremony.*

On the day preceding the commencement of the rites and associated festivities, members of both clans and all castes gather along the banks of the Be-Malai estuary; the people of Atabai on the northern, and the people of Balibó on the southern, side.

A large communal rotunda is built on the Atabai side of the estuary, and a bridge is constructed to span the water and facilitate social intercourse between the *Rato* and *Patcha* castes of Atabai and Balibó. On the night before the sacrificial rites take place they mingle freely in the rotunda, dancing and singing far into the night.

The bridge and rotunda are constructed from bamboo and decorated with thin sheathes of young bamboo curled and fastened with liana vine.

(3) Until recent economic and social influences contributed to a break in age-old customs, it was virtually impossible for marriages to be contracted between members of differing social stratum.

The footpath of the bridge is formed of split bamboo and the handrails have archways of the same material fixed at frequent intervals. These are decorated with spirals of bamboo. From the apex of the arch is suspended a coconut shell filled with oil and having a bamboo 'wick'. These lamps are lit immediately the sun has set, and are constantly replenished throughout the night.

The banks of the estuary are also illuminated by placing large bamboo poles decorated in a similar manner at one metre intervals on both sides of the water. A coconut shell to hold the oil is firmly fixed in the hollow apex of the poles.

At the setting of the sun the 'victim' (plate 10C) retires to a specially prepared *Palapa*[4] hut, which is built well away from the two celebrating groups of people (plate 10B). From the time he crosses the threshold of the hut he may not hold conversation with anyone, nor partake of food or drink until the rites of sacrifice are completed.

On the following morning the human 'victim' is led to the edge of the water and struck on the head from behind with a long wooden stave. Falling, he feigns death and is immediately bound, covered with a *tarafa* (a native fishing net), and a new and beautifully woven *tai* (a long skirt-like garment worn by Timorese men), is folded and placed beneath his head (plate 11A). This method of placing the *tai* is identical with normal burial practice among these people. A small black boar (*Sus scrofa vittatus*) is then brought close to him and killed by having a long thin-bladed knife plunged into its heart. The body of the animal is then pressed by the executioner causing the blood to well through the opening into the current of the water in the estuary, for approximately twenty minutes. This process is termed by the Timorese 'giving to the water'. During the time that the blood of the pig is entering the water, there is complete silence among the groups congregated on both of the estuary banks and the people surrounding the 'victim' and the dead body of the boar (plate 10A, plate 11AB).

When the blood has ceased to flow from the boar, a slow procession of decorated boats (plate 10A, plate 11B) leaves the shallow tree-lined channel in the south-east corner of the estuary, near the point where the man has been 'sacrificed'.

(4) *Palapa* is the term used by the Timorese for poorer less durable types of bamboo construction.

The leading boat (a, plate 10A) is decorated with arches of spiralled bamboo, and a large bleached cotton fabric square of Timorese weave is fastened, like a banner, across the prow of the boat. On this are inscribed various signs and figures.

The *Rato* men of Balibó are seated in the boat, and the profuse decorations almost obscure them from the gaze of the people on the banks of the estuary.

Instead of wearing their usual colourful costumes they are dressed in white garments, and are without the usual gold, coral and goat-hair ornaments indicative of the ruling caste of Timor.

Towed by the leading boat in the procession, is a second boat (b, plate 10A) carrying a fisherman standing in the prow, with his *tarafa* ready to fling into the water. Behind him is a portion of tree stump (which, I was told, is very *lulic*)[5] also covered by a bleached cotton cloth inscribed in a similar manner to the banner of the leading boat (g, plate 10A). Kneeling in front of this stump is a *Rato* of Balibó. The steersman sits in the stern guiding the boat gently with smooth strokes from a large single paddle which enters the water without a splash. It is essential that the water is not disturbed in any way.

The remaining boats in the procession (c, c, c, c, plate 11B) which contain the *Patcha* of Balibó, all carry *lulic* sticks. These are branches forked in a particularly significant manner[6] and bear smaller pieces of inscribed cloth (d, d, d, d, plate 11B). Unfortunately I was unable to obtain a close enough view to observe the markings on these 'banners'.

The boats containing members of the ruling caste and nobility of Atabai (f, plate 11B) are moored along the processional route, while the *Acano* (lowest caste) of both clans line the estuary banks (e, plate 10A).

When the fisherman standing in the prow of the boat immediately behind the decorated leader (a, b, plate 10A) casts his net into the water, every other fisherman in the following boats (c, c, c, c, plate 10A, 11B) then follows his example. This is the signal for the ending

(5) *Lulic*—having sacred supernatural power. The term is used freely as an adjective and a noun. Sometimes, though less frequently, as a verb.

(6) *Lulic* sticks. It is often difficult for the Timorese to acquire *lulic* sticks as they may not be cut, or shaped artificially, and the stick must "speak" to the owner before he can acquire it.

of the complete silence which has marked the proceedings until this moment. At the same time all the Atabai boats put out from the shore to start fishing (f, plate 11B) and there is intense rivalry to gain the honour of being first to reach the central channel of the estuary.

The *Acavo* caste of both clans rush from the banks into the shallows, dancing, shouting and singing; I was informed that this was necessary 'in order to stir up the mud and make the fish drunk'.

Once the leading fisherman of the processional boats (b, plate 10A) has cast his net and made his first catch, the fishing net (*tarafa*) is removed from the 'victim' and his bonds are cut; he rises to a squatting position on the estuary bank and, holding his nose in his hand, keeps his back to the water.

Preceded by the *Rai-lulic,* who carries an unsheathed ceremonial sword on the open palms of his hands with his arms fully extended, the 'victim' walks along the ceremonial path[7] to a secluded banyan tree, still maintaining the stance shown at plate 10C, leaving the *tai* on which his head has been lying, and a stave broken in two under the *tarafa* (net) on the bank of the estuary.

The female buffalo tethered to the tree has been, before the commencement of the ceremonies, a focal point of interest to all members of both clans but, from the commencement of the rites involving the shedding of blood, only selected adult males of Atabai and Balibó (the two clans involved in the ritual) are permitted to the sacrificial area, and only the *Rai-lulic* may touch the buffalo.

Without looking at the buffalo tethered to the banyan tree, the 'victim' goes to the opposite side and squats down with his back against the same tree, still maintaining the 'arms folded' position (plate 10C), with his head sunk upon his chest.

The *Rai-lulic* approaches and offers betel nut on the tip of the ceremonial sword first to the buffalo, and then to the male 'victim' who accepts the offering directly into his mouth. The 'victim' chews for a few seconds while the *Rai-lulic* retreats still facing the man then, turning his head from right to left, the 'victim' expectorates five times in a semi-circle, finally returning his head to a frontal position and letting his chin fall upon his chest. He then continues chewing.

(7) The ceremonial path to the tree of sacrifice is shown on a, plate 10 (C). The stakes which border the edges of the path are decorated in a similar fashion to the stakes which line the banks of the estuary, but do not carry lights.

Returning to the buffalo, the *Rai-lulic* inserts the ceremonial sword into the vaginal passage and slowly increases the strength and penetration of the sword thrusts until, advancing beyond the duodenum, the point of the sword encounters and eventually pierces the major organs of the body.

With each bellow of the wounded buffalo, the 'victim' expectorates five times in a semi-circle. When the animal has finally died, and been disembowelled by the *Rai-lulic,* the 'victim' rises from his squatting position and, picking up the entrails, walks to the water's edge to 'offer them to the water'. This offering is made in a similar manner to that of the pig's blood, *i.e.,* it is allowed to float into the current of the estuary before being released.

Following this ritual the *Rai-lulic* dissects the carcass of the buffalo and, after reserving certain portions for himself, hands the rest in equal portions to the representatives of his own people, the Balibó. The 'victim', although a Balibó man, does not receive any of the sacrifice.

The representatives of Atabai who have observed this part of the ceremony are not handed any portion of the buffalo.

The 'victim', although now free to walk along the estuary banks, observing the fishing and partaking of the catch, may neither participate, nor handle the live fish.

(*d*) *Economic aspects of the fishing ceremony.*

The entire populations of Balibó and Atabai fish continuously for two or three days following the conclusion of the sacrificial rites. Quantities of fish and prawns are caught in all stages of growth, but only the biggest of the catch is immediately utilized, and no attempt is made to preserve the surplus for future use. The smaller specimens caught are thrown upon the estuary bank to rot in the sun.

In view of this wanton wastage and the apparent lack of appreciation of the dangers of overfishing in the area, it is fortunate that fishing only takes place at widely spaced intervals.

(*e*) *Function of the ceremony.*

The fishing rites of Be-Malai have a two-fold significance. To commemorate the myth of the creation of the estuary and to perform the ceremony which, it is believed, will ensure a continuation of an abundant supply of fish at Be-Malai.

The ceremony also propitiates the salt-water crocodiles who inhabit the estuary and the Ombai Strait so that, during the days of festival, fishing may be safely undertaken.

It is significant that fishing does not take place at Be-Malai except at the times of festival.

The Timorese of this area display a reverence and fear toward these crocodiles and, should a woman be taken by one of them, her male relatives consider this to be a sign that the ancestor is so well pleased with her that he wishes to take her for a wife. If a male is seized he is usually considered to have offended his crocodile ancestor by displaying too much arrogance in his manhood.

SUMMARY

This paper describes and illustrates the fertility sacrifice of Be-Malai, Portuguese Timor. It records the area where the rituals are carried out, the associated myth and rites and comments on the functions of the ceremony and its economic and religious implications.

ACKNOWLEDGMENTS

I should like to record my indebtedness to Governor Themudo Barata and the members of his Administration for the great assistance given to me during field work in Timor. My thanks are also due to Hedley C. Brideson, Principal Librarian and the Libraries Board of South Australia for their generous help and interest in my work; and to Charles P. Mountford whose advice and encouragement has proved invaluable to me.

RESUME

Ce journal décrive et illustre la cérémonie de pêche et la sacrifice de fécondité de Be-Malai, en Timor portugais. Ceci enregistre l'endroit où arrivent les rites, le mythe et les rites associés de la fonction de la cérémonie et des ses implications économiques et religieuses.

EXPLANATION OF PLATES 10 TO 11

PLATE 10

(A) Front section of procession of decorated boats belonging to *Rato* and *Patcha* castes of Balibó.
(B) Hut occupied by Balibó man prior to commencement of ceremony.
(C) Balibó man used as 'sacrifice'.

PLATE 11

(A) Covering the 'victim' with a fishing net (*tarafa*).
(B) Rear section of procession of decorated boats belonging to *Rato* and *Patcha* castes of Balibó.

A

B

C

A

B

TWO STONE PESTLES FROM WESTERN PAPUA AND THEIR RELATIONSHIP TO PREHISTORIC PESTLES AND MORTARS FROM NEW GUINEA

By GRAEME L. PRETTY, Curator of Archaeology,
South Australian Museum

Plates 12-13 and text fig. 1-2

SUMMARY

Record is made of a stone pestle collected near the Oriomo River, south-west Papua, in 1928. The owners' story that it came to their fathers from the north-west is supported by study of the distribution of stone implement trade routes in Western Papua and by a report of another pestle recently discovered at a locality on the headwaters of the Fly River. This second pestle is also described. The significance of both is discussed in relation to other pestles and mortars from New Guinea.

INTRODUCTION

Many stone pestles, mortars and other objects labelled as "prehistoric" have been found in New Guinea over the last fifty years. The present-day people frequently put them to various uses, though betraying no certain knowledge of their original function. Of late, these objects have been the subject of revived interest (Bulmer 1964, Bulmer and Bulmer 1964, Chappell 1964, Galis 1964, Pretty 1964 a, b). The following account describes two pestles, one of them surmounted by the figure of a bird. Whereas the majority of these objects have been recovered from the Central Highlands, the bird pestle was collected in the far South of the Western Division, and therefore presents a new facet to the problem of their distribution. The possible route by which this specimen could have arrived at such a locality will be discussed.

STONE PESTLE FROM WONIA, UPPER ORIOMO RIVER

This specimen (plate 12) is in the collection of Mr. C. W. Marshall of Sydney, who has kindly permitted the writer to examine and describe it. In 1928 Mr. Marshall was camped by Wonia near the

headwaters of the Oriomo River in south-west Papua (see fig. 2). Pinoegali or Pininchelly, the site of an oil exploration bore, was just by Wonia. His diary entry for Saturday 14th July, 1928, notes:

> "Bought a most peculiar stone today of basalt—very weathered. Unga [of] Wonia [village] gave it to me. It was found [i.e. "came from": *findim* in Pidgin] near Pininchelly (that [is] Wonia Bore). He calls it a totem signify[ing] a (white) stone club. The Borum is the club with a handle. He showed me how this was grasped round the middle and used in the hand. Am very struck with the design".

Marshall was then engaged on a cross-country traverse, while surveying for Oriomo Oil Ltd. He had been working in this area for about three months and had made it widely known that he was anxious to acquire stone objects. This day (14th July, 1928), while sitting in camp, the boss-boy informed him that some old men wanted to speak with him. He consented, and a deputation of elders led by Unga, one of his Wonia carriers, presented the specimen to him. Marshall, in return, gave suitable presents of his own.

So far as he could ascertain they had used it as an execution or sacrificial club. Before this it had come to their fathers from the north-west and belonged to something they had little conception of or were reluctant to talk about. Sensing, from their clicking tongues, that to press further would cause ill feeling, Marshall let the matter rest.

These people had a story that in past times a woman also had come from the north-west, bringing bows, arrows, and knowledge of fire to their fathers.

The Wonia pestle (plate 12, 13A) consists of a bird-like figure, joined by a long stem to a bulbous base. The head and beak are well formed and eye sockets are clearly discernible. The neck is long and elongated and is continuous with the stem. The outstretched wings have sharply formed margins and curve around the stem to form a short, blunt, rounded tail. There is a faint flange separating the stem from the bulbar base. Though almost perfectly symmetrical, closer examination shows that a line running across the upper margins of the wings does not meet a line through the neck and stem at right angles. The bulbar base is slightly flattened behind.

It measures 30 cm high and 10 cm across the wings. The base is 8-10 cm in diameter. The broken tip and underside of the beak was the result of an accident shortly after it was brought back to headquarters.

Marshall had been anxious to learn something of the nature of the stone and, at the time, passed it on to Oil Company geologists for identification. They suggested andesite as being the most likely rock type. This general identification is confirmed by Dr. D. W. P. Corbett, Curator of Minerals and Fossils, who suggests that, in the absence of a thin section, the composition would seem to be largely of felspars, very heavily weathered to clay, together with dark minerals. A xenolith, probably of epidote, can be seen projecting from the external surface of one of the wings (plate 13A). Unfortunately the state of weathering gives no real indication of its age.

Casts of it are in the South Australian Museum collections and are registered as No. A55227.

STONE PESTLE FROM OLSIVIP, FLY RIVER HEADWATERS

Of close relevance to study of the Wonia pestle is the recent discovery of another pestle (plate 13B) near Olsivip (Olsobip), Upper Fly River, Western Papua. It was obtained by Patrol Officer R. Hoad of the Territory Administration and brought to my attention by Mr. B. Craig of Telefomin (personal communication, 22nd October, 1964). It was reported to have been dug up somewhere in the vicinity before being placed in the men's house. It measures 18 cm in length, and 8 cm diameter at the bulb, which has been criss-crossed with bands of red paint. It was described as made from a white coloured macro-crystalline material—perhaps a granite (B. Craig, *ibid.*). The specimen was said to be intended for the Port Moresby Museum.

The unexpected discovery of an archaeological stone pestle at Olsivip gives some substance to the report that, before the last War, stone pestles were found at nearby Bolivip by Mr. Ward Williams of the Oroville Gold Dredging Company (personal communication, Mr. J. A. Davidson).

DISCUSSION

The two specimens just described are paralleled by many pestles from other parts of the territory. They do not seem to be a culture trait of the present-day people and are usually found in the bush or

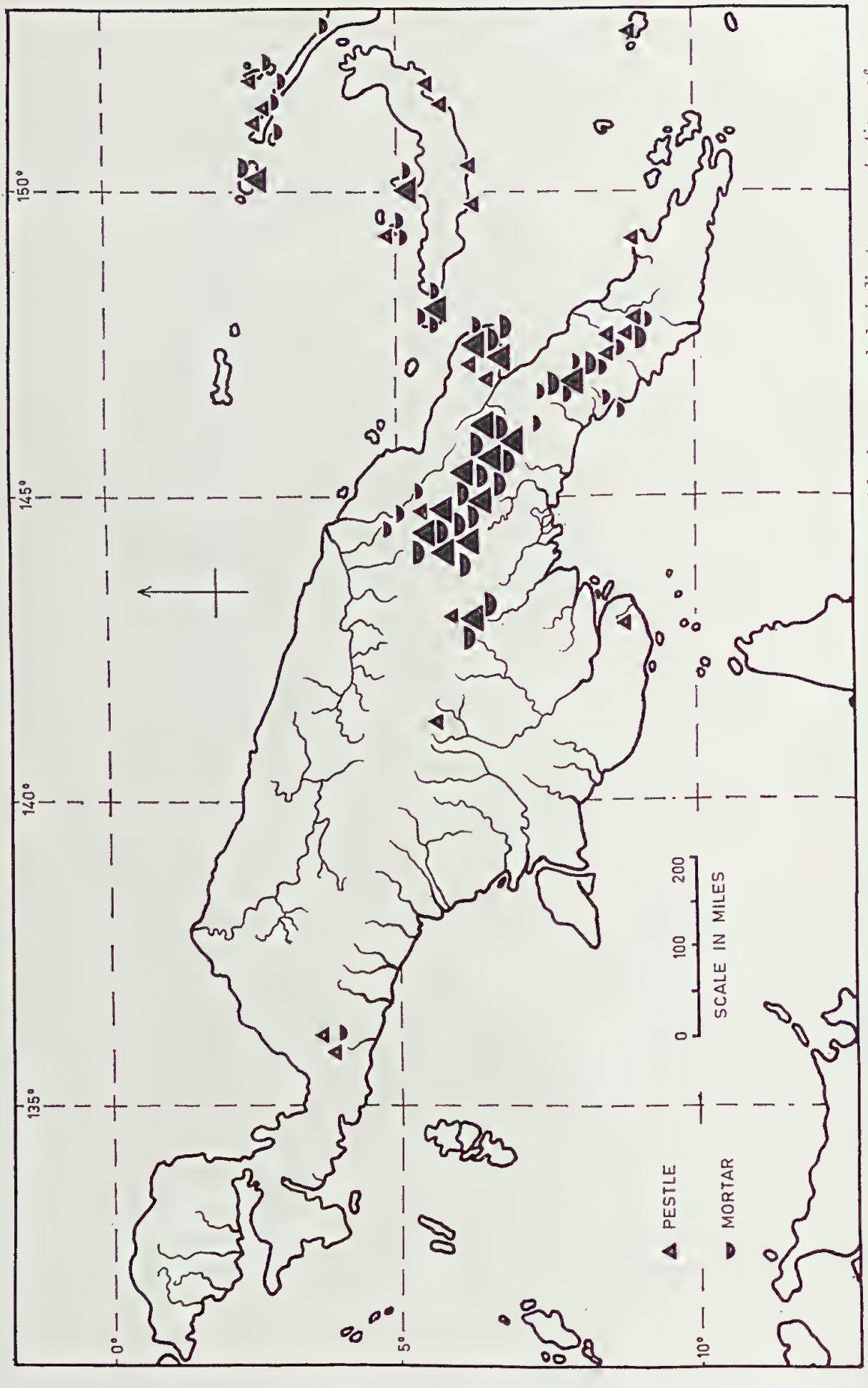


Fig. 1. Map of New Guinea showing distribution of stone pestles and mortars (the larger symbols indicate concentrations of three specimens). Specimens of uncertain locality are not included.

dug up in native gardens, often to the mystification of their discoverers. A considerable variety of these prehistoric stone objects have been described; club heads, perforated blades, rings, and carvings in human and animal forms. The most characteristic types of this assemblage are the pestles and the mortars, which have been fully discussed by Bulmer and Bulmer (1964, pp. 67-72). The Wonia pestle is almost exactly paralleled by a magnificent specimen described by Captain F. R. Barton (1908).

A tentative distribution map of the pestles and mortars has been prepared and includes all published specimens presently known to me (fig. 1). It also includes three unpublished records, two of which have just been described, while the third, a figure of a bird with broken stem from Laiagam, was examined only briefly before its owner took it back to the Territory in 1962. These objects seem to be densely distributed in the Central Highlands of Australian New Guinea, being at present concentrated in the Wahgi Valley, and extending south-eastward along the Central Ranges to Kokoda (8° 52′ S., 147° 45′ E.). They are also frequently found along the north-east coast where the high land comes close to the sea, and are scattered throughout the Eastern Archipelago and in the Solomons, where they may prove to be related to the *poi* pounders of Polynesia. They do not appear to occur in the Trobriands or the Admiralty Islands. They are almost unknown from south of the Central Mountain Range, though Williamson (1912, pp. 75-76) has reported specimens from the ridges beyond Mafulu (8° 30′ S., 147° 01′ E.). Both the "pestles" from Papua reported by De Vis (1905), Lyons (1911, p. 80), McCarthy (1949, p. 158, plate IX, fig. 9), and the stone bowl reported by Bühler from Yule Island (1946-49, fig. 1a, cf also Strong, 1924, p. 98, fig. 2) seem to fall into a different category. These new records, together with the specimens from the Wissel Lakes (3° 55′ S., 136° 15′ E.), West New Guinea, reported by Galis (1964, p. 255), suggest that these objects may occur over a far wider area than has been supposed. Any conclusions about the significance of this distribution should be left in abeyance until the intervening areas are more closely explored. As can be seen from the map, the position of the Wonia pestle is quite apart from the rest of the distribution of these objects, even in its wider sense. It will be the aim of the following discussion to say something of how the Wonia pestle could have arrived at such a locality.

Although the function of these objects is usually lost, the present-day people will put those they find to use, usually as magic stones, but

sometimes in other ways, *e.g.*, filling mortars with water for mirrors (Chinnery, 1919, p. 272; Murray 1932, p. 13; Williams 1930, p. 37; Williamson 1912, p. 76). The Wonia pestle, although typologically quite clearly a pestle and known by the natives to be of exotic origin, was said to have been used as an execution or sacrificial club. However, there is no instance of ritual killing recorded for the Oriomo area.

In their mode of manufacture, the pestles and mortars appear to be made by the same pecking and polishing technique as that most recently employed in New Guinea stonework. Stone implements in New Guinea are derived from two principal sources, quarries and river pebbles. Blades from quarries are made either from flaked stone blanks, shaped and ground to an edge on the spot, or traded out in their flaked form and brought to a finish in surrounding areas (Vial, 1940). Otherwise, blades are made from water-rounded river pebbles, either polished into shape directly, or split and chipped into the desired shape before polishing (Le Roux 1948, pp. 425ff). Clubs also appear to have been made from rounded pebbles only, and not from quarried blanks. Haddon (1900) reported several instances of hardly altered pebbles, bored and fitted to handles, serving as clubs. Williams (1930, p. 83) describes how Orokaiva men manufactured pineapple club-heads from river pebbles.

Although it is possible that some may have been fashioned from quarry blanks, yet from their form and variation in size, one would expect pestles and mortars also be be made from rounded river pebbles. In Chappell's (1964) account of a modern instance of mortar manufacture, the specimens were described as having been made from sandstone river boulders. Hence, in seeking the most likely source of the Wonia pestle, one should look within the whole context of stonework in that part of Southern New Guinea.

Western Papua, from the edge of the mountain plateau south to the coast, an area which for administrative purposes is known as the Western Division, is alike in the almost total absence of hard stone suitable for making stone implements (Murray, 1914, p. 23; Haddon, 1917, p. 194; Wirz, 1922, p. 114; Landtman, 1927, p. 33; Williams, 1929, p. 392; Williams, 1936, p. 103). Consisting, for the most part of flat swampy areas and lakes, it is intersected by two large winding rivers, the Fly and the Strickland, with their tributaries. In the far South, along the coast of the Western Division, a low synclinal ridge brings the limestones well above sea level and diverts the Fly River eastward and into the Papuan Gulf. Even here, save for the small

granite outcrop at Mabaduan, there is no hard stone. The peoples of the area are for the most part headhunters and nomads, moving from hunting shelter to longhouse in lengthy dugout canoes. They extend westwards well into Indonesian territory, at least as far as the Eilanden River (Thomson 1953), and may all have the common origin postulated by Wirz (1933, pp. 114-115). Living as they do in an area devoid of hard stone, they are entirely dependent on trade and conquest for their stone implements. Therefore, by study of the literature, it should be possible to determine both the routes along which stone implements were distributed throughout the area, and the sources of their manufacture. Further, these trade routes, being physiographically influenced, are likely to hold as much for prehistory as for the immediate ethnographical past. It may then be possible to say something of how the Wonia pestle came to its final destination.

When the distribution of stone implements and the respective trade routes are plotted on a map (fig. 2),[1] it will be seen that there were two main sources of manufacture; one in the area of the Fly River headwaters and the other in the Torres Straits islands. Although there are new records of blade quarries in the former region, they will be described elsewhere, and only that evidence which relates to stone pebble sources will be discussed here.

The headwaters of the Fly River have pebbles in abundance. Austen (1923, p. 344) reports that on the Ok Tedi tributary (6° 10′ S., 141° 08′ E.), clubs were made locally. Davidson (personal communication, 10th December, 1964) was in the same area and saw clubs made from river pebbles and perforated with a long stone. At a point on the Upper Fly where this progress was impeded by shingle bars, D'Albertis (1880, Vol. 2, p. 86) made his largest collection of stone implements. Less direct evidence is Murray's (1914, p. 23), who writes that, as he travelled downstream, the stone blades tended to become smaller in size and more highly valued by their owners. Although there are great quantities of river pebbles (Wilkinson, 1888, p. 203; Hides, 1936, p. 40), there is no evidence of stonework along the thinly populated Strickland River. In Torres Straits, according to Landtman (1927, p. 34) implements were made from volcanic pebbles taken from the seabed. This is supported by Haddon (1935, pp. 76-77), who described what must have been an extensive stone implement manufacturing station on Long Island.

(1) Such a distribution map of the Western Division is all the more pertinent since insufficient material forced Haddon to omit it from his 1900 paper.

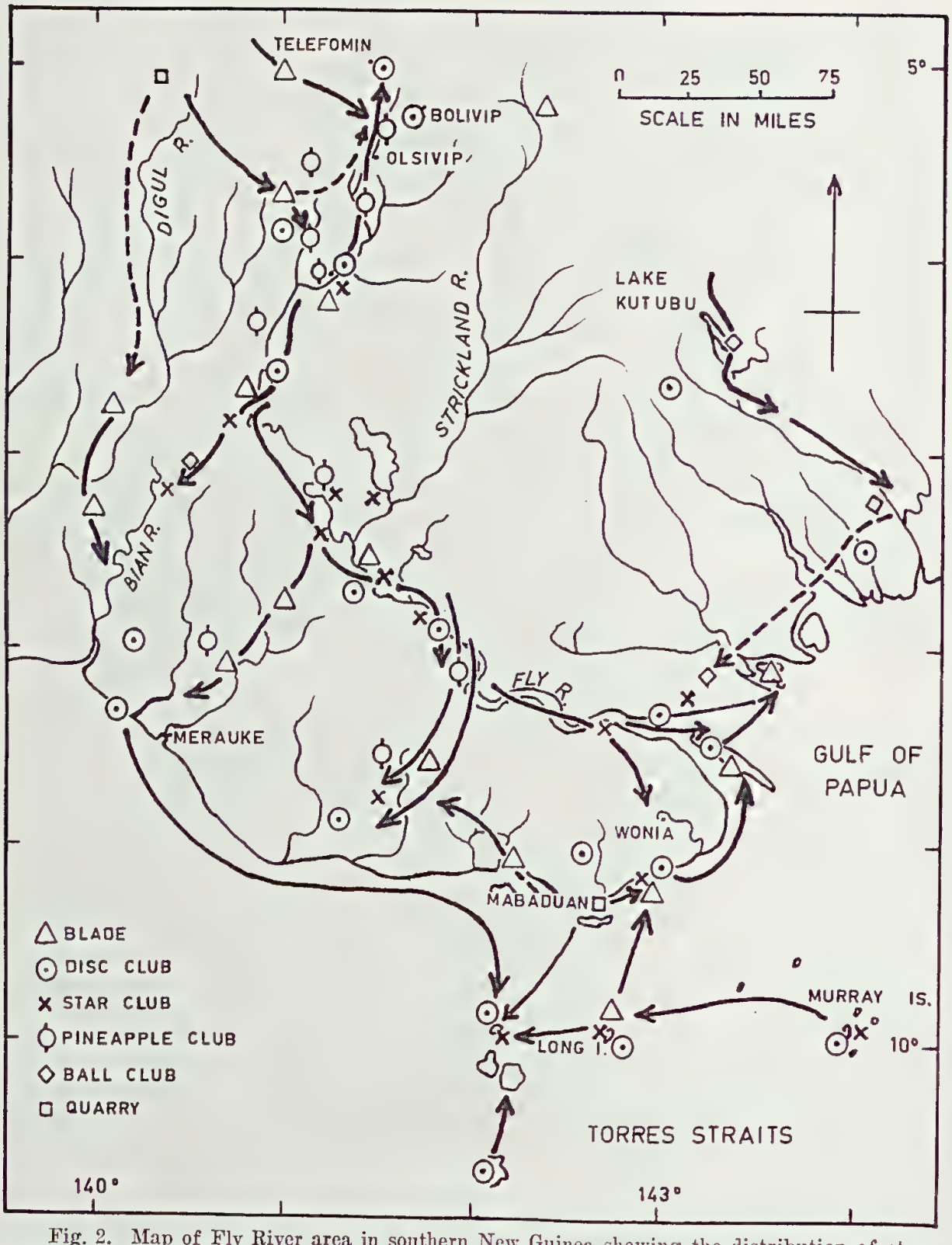


Fig. 2. Map of Fly River area in southern New Guinea showing the distribution of stone implements and their trade routes.

On the other hand, there are a few reports of local manufacture in this region. Landtman (1927, p. 287) reports granite stones with sharpening marks from Mabaduan, where the granite outcrops as Mabaduan Hill. Marshall (personal communication, 5th September, 1962) found a grinding stone in an abandoned village seven miles east of Wonia. Williams (1929, p. 384) and Wirz (1946, p. 80) mention grinding stones for blades which, though of unknown origin and revered as cult objects, could still be evidence of local manufacture.

From the manufacturing stations in the Fly headwaters the trade routes took a south-east direction following the trend of the river. Wirz (1922, p. 114), in noting the presence of stone blades on the coast between the Bian and Merauke Rivers, distinguished two types, one of which came from the Fly River to the north-east. Williams (1936, pp. 416, 428) reports that stone implements came to the south-coast hinterland from the mid-Fly, though a few come from the coast itself. According to Marshall (personal communication, 19th October, 1962) stone implements entered the Oriomo district through the Fly River people, who traded them from up-river. Chalmers (1903, p. 122) describes the Kiwai people of the Fly Estuary as obtaining their stone clubs from up-river to the west. Trade routes also branched out from the Torres Straits islands to the south coast, but their relative distance from the distribution of pestles and mortars precludes the possibility of the Wonia pestle having originated there. Therefore the major direction of entry of stone implements into the Wonia area would seem to be from the north-west along the length of the Fly River. Even if a specimen such as the Wonia pestle were not manufactured in the region of the Fly headwaters, it is likely that it was distributed from the same source. This, together with the discovery of a similar specimen at Olsivip, would tend to confirm the old men's story that the Wonia pestle came to their fathers from the north-west.

CONCLUSION

In an area devoid of stone and whose natural routes were the waterways of the great rivers, stone implement trade routes of former times should bear close relationship to contemporary routes of distribution. Therefore the Wonia pestle would probably have travelled down to the Oriomo area from the Fly headwaters, as is hinted by local tradition. The recent discovery of a parallel specimen at the source of the Fly adds to this supposition and relates the Wonia pestle more closely to the "prehistoric" pestles and mortars of the Central New Guinea Highlands.

ZUSAMMENFASSUNG

Dieses Papier beschreibt eine Pistille die nahe dem Fluss Oriomo, in Süd West Papua, in 1928 erhalten wurde. Der Bericht der einstigen Besitzer, dass dieselbe von ihren Vorvätern vom Nordwesten kam, ist bekräftigt bei Studien der Verteilung von Steinimplementwegen in West Papua, ebenso durch einen Report einer weiteren Pistille, welche jüngst in der Umgebung der Quellwasser des Flusses Fly entdeckt wurde. Diese zweite Pistille ist ebenfalls beschrieben. Die Bedeutung beider, verglichen mit anderen Mörsern und Pistillen von Neu Guinea, ist ebenso behandelt.

ACKNOWLEDGMENTS

I am indebted to Mr. C. W. Marshall for permission to publish an account of his pestle, and for the notes, maps, and extracts from his journals. Mr. B. Craig of Telefomin, T.P.N.G., supplied field data and has kindly provided the photograph of the Olsivip specimen (plate 13B). Mr. J. A. Davidson of Melbourne also provided data. Mr. N. B. Tindale, Curator of Anthropology, was of much assistance in the preparation of the manuscript.

REFERENCES

Austen, L. A., 1923: Tedi River district of Papua. Geogr. J., London, 62(5): 335-349.

Barton, F. R., 1908: Note on stone pestles from British New Guinea. Man, London, 8, no. 1: 1-2, and pl.

Bühler, A., 1946-1949: Steingeräte, Steinskulpturen und Felszeichnungen aus Melanesien und Polynesien. Anthropos, Freiburg, 41-44: 225-274, 577-606 and 4 pls.

Bulmer, R., 1964: Edible seeds and prehistoric stone mortars in the highlands of New Guinea. Man, London, 64, no. 183: 147-150.

EXPLANATION OF PLATES 12 TO 13

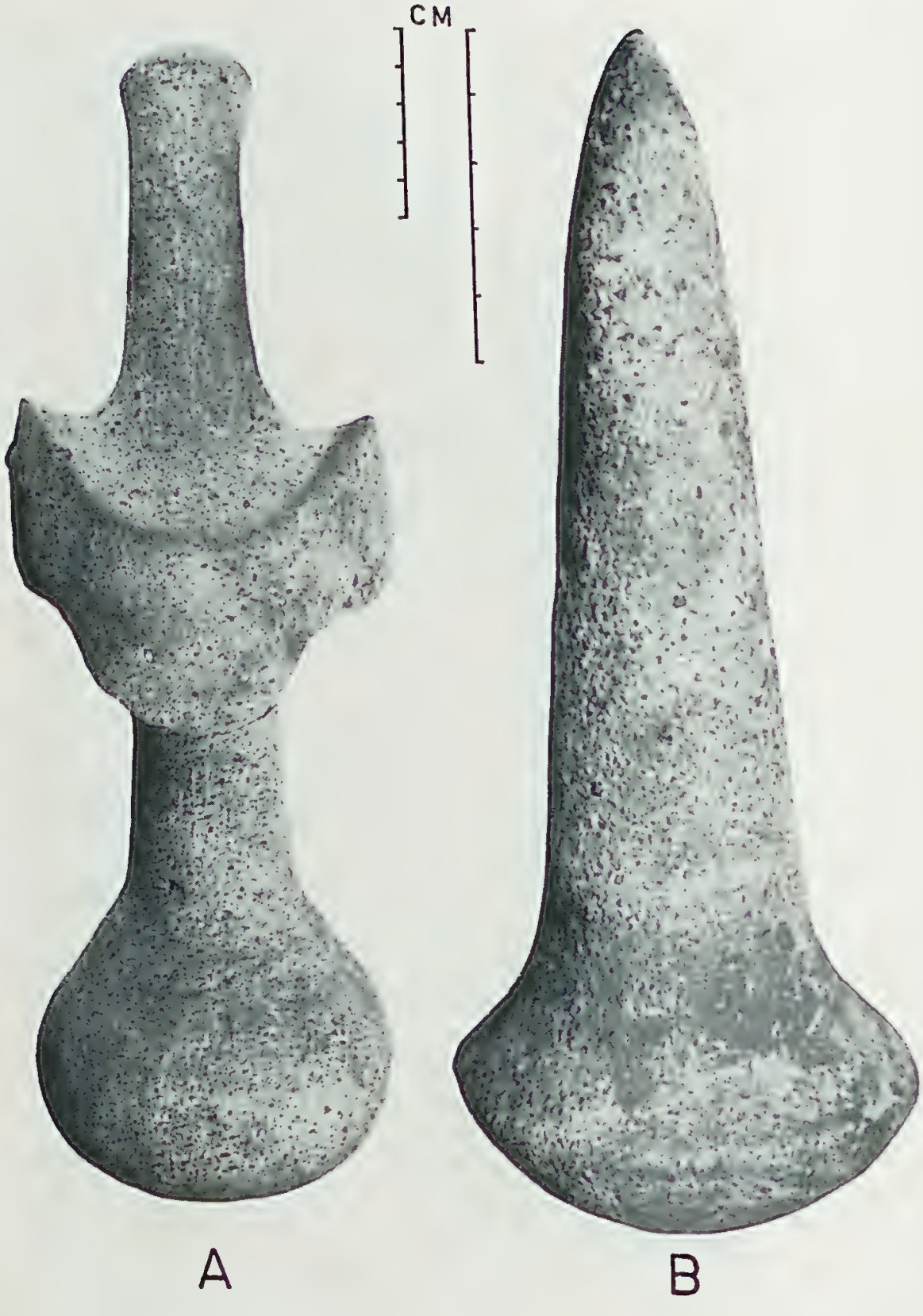
PLATE 12

Stone pestle from Wonia, south-west Papua, three-quarters view.

PLATE 13

A. Stone pestle from Wonia, south-west Papua, back view.

B. Stone pestle from Olsivip, western Papua (photo.: B. Craig).


CM
A
B

Bulmer, S. and R., 1964: Prehistory of the Australian New Guinea Highlands. Amer. Anthrop., Menasha, 66(4): 39-76.

Chalmers, J. (late), 1903: Notes on the natives of Kiwai Island, Fly River, British New Guinea. J. R. anthrop. Inst., London, 33: 117-124.

Chappell, J. M. A., 1964: Stone mortars in the New Guinea highlands: a note on their manufacture and use. Man, London, 64, no. 182: 146-147.

Chinnery, E. W. P., 1919: Stone work and goldfields in British New Guinea. J. R. A. anthrop. Inst., London, 49: 271-291, and pl.

D'Albertis, L. M., 1880: *New Guinea, what I did and what I saw.* London, 2 vols.

De Vis, C. W., 1905: Papuan Charms. Ann. Qd. Mus., Brisbane, 6: 32-35, and 2 pls.

Galis, K. W., 1964: Recent Oudheidkundig Nieuws uit Westelijk Nieuw-Guinea. Bijdr. Taal-, Land-, Volkenk., The Hague, 120(2): 245-274 and 8 pls.

Haddon, A. C., 1900: Classification of the stone clubs of British New Guinea. J. R. anthrop. Inst., London, 30: 221-250, and 5 pls.

——— 1917: Note on the Gogodara (Kabiri or Girara). Man, London, 17, no. 132: 193-194.

——— 1935: *Reports of the Cambridge Anthropological Expedition to Torres Straits. General Ethnography.* Cambridge, 1.

Hides, J. G., 1936: *Papuan Wonderland.* London.

Landtman, G., 1927: *Kiwai Papuans of British New Guinea,* London.

Le Roux, C. C. F. M., 1948: *De Bergpapoea's van Nieuw-Guinea en hun Woongebied.* Leiden.

Lyons, A. P., 1911: Magisterial Report for the Lakekamu Goldfield. Papua Annual Report 1911, Melbourne: 75-80, and App. D (1).

McCarthy, F. D., 1949: Some prehistoric and recent stone implements from New Guinea. Rec. Aust. Mus., Sydney, 22: 155-163, and 4 pls.

Murray, J. H. P., 1914: Visit to the Fly and Strickland Rivers. Papua Annual Report 1913-14, Melbourne: 17-25.

——— 1932: Stone mortar on the Kiapou. Papua Annual Report 1930-31, Canberra: 13.

Pretty, G. L., 1964a: Stone objects excavated in New Guinea. Man, London, 64, no. 138: 117.

——— 1964b: Stone figure of a crested cockatoo from Melanesia. Man, London, 64, no. 220: 183-184.

Strong, W. M., 1924: Stone mortars and pestles *in* More rock paintings from Papua. Man, London, 24, no. 74: 97-99, and pl.

Thomson, Donald F., 1953: War-time exploration in Dutch New Guinea. Geogr. J., London, 119(1): 1-16 and 6 pls.

Vial, L. G., 1940: Stone axes of Mount Hagen, New Guinea. Oceania, Sydney, 11(2): 158-163, and pl.

Wilkinson, C. S., 1888: Report on the geological specimens from New Guinea, collected by the exploring expedition of the Geographical Society of Australasia. Trans. R. geogr. Soc. Aust. N.S.W. Br., Sydney, 3-4: 203-206.

Williams, F. E., 1929: Rain-making on the River Morehead. J. R. anthrop. Inst., London, 59: 379-397, and 2 pls.

——— 1930: *Orokaiva society.* Oxford.

——— 1936: *Papuans of the Trans-Fly.* Oxford.

Williamson, R. W., 1912: *Mafulu mountain people of British New Guinea.* London.

Wirz, P., 1922: *Die Marind-Anim von Holländisch-Süd-Neu-Guinea, Die materielle Kultur der Marind-anim.* Hamburg, 1(1).

——— 1933: Head hunting expeditions of the Tugeri into the Western Division of British New Guinea. Tijdschr. ind. Taal- Land- en Volkenk., 73: 105-122, and pl.

——— 1946: Einiges über die Steinverehrung und den Steinkult in Neuguinea. Verh. naturf. Ges. Basel, 57: 75-117.

STONE IMPLEMENT MAKING AMONG THE NAKAKO, NGADADJARA AND PITJANDJARA OF THE GREAT WESTERN DESERT

By NORMAN B. TINDALE, South Australian Museum

Fig. 1-23

SUMMARY

This paper describes observations at a native mining place in the Mount Davies area of South Australia where Nakako and Pitjandjara men quarried stone for the making and hafting of stone knives, which they call ['tjimari]. It also records the making of ['kandi 'tjuna], hafted stone adzes (or chisels) among the Ngadadjara near Gill Pinnacle, east of the Rawlinson Ranges, Western Australia. A supposedly new technique of pressure flaking is described and named as the rolling pressure technique.

The Nakako tribespeople first encountered white men in 1961. Four years previously deserted camps had been seen by the writer during a visit to the Blyth Range. Their territory lies south of the Blackstone Range, and west of Bell Rock Range, in Western Australia.

There is a general discussion on some Australian archaeological implement types which parallel those obtained from these people, and in particular an account is given of the implement called ['kandi] by living Western Desert folk.

INTRODUCTION

In November 1963 opportunities occurred to see some stone-implement making techniques and visit a native mining place for implement stone. This occurred when we were visiting two groups of aborigines, still nomadic in a large tract of Western Australian country between the Rawlinson and Blackstone Ranges and ranging eastward into the Tomkinson Ranges, at the far north-western corner of South Australia. The occasion was the combined excursion to Gill Pinnacle and to Mount Davies by Drs. W. V. Macfarlane and J. R. Sabine of the National University in Canberra with Messrs. P. Aitken,

Assistant Mammalogist and the writer, of the South Australian Museum. A preliminary report of the work of Dr. Macfarlane, dealing with water and salt metabolism of the aborigines, has been given in *Man in the Pacific,* Honolulu (3 April, 1964) and the results of our blood group studies have appeared in the Journal *Oceania* under the joint authorship of Simmons, Graydon and Tindale (1964, 35(1) pp. 66-80).

In over a dozen previous visits to the Western Desert the present writer has had opportunities of seeing implements made and in use. Some observations have been recorded, Tindale (1941, 1957) and Tindale and Noone (1941).

On earlier occasions native mines near Macdonald Downs, Haast Bluff, Mount Liebig and Yuendumu in Central Australia had been visited with aborigines who have known how to make stone implements, but in general they were persons who had not practised their craft for some years. In the present instance the quarry or mine was in use by men still depending on its stone for their tools; hence its particular interest. The study of this mine has afforded much satisfaction since the results suggest that what had been learned at other mining places was equally sound and useful.

In this paper no attempt is made to trace the history of knowledge of stone-implement making techniques, even of the few types discussed; the principal side references are to earlier personal observations and to a few notes directly relevant to observations made during our 1963 fieldwork.

The following are the principal stone implements of the Nakako, Ngadadjara and Pitjandjara peoples and the terms they apply to them. It happens that their names are all held in common:—

'kandi 'meru, a general purpose adze-knife, hafted, with *Triodia* resin, on to their spearthrower ('meru, 'mero).

'kandi 'tjuna, a hafted adze or chisel; either single or double-ended, in the latter case one end is usually an engraving tool.

'tjimari, a resin-hafted knife.

'kandi 'minu, simple flakes used for the subincision operation.

'kandi 'pituru, sharp-pointed flakes, often with resin handle, used in blood letting from the arm, ['minata]; the source of this blood is secret and sacred to men; the flakes are also

used in cutting the subincised urethra to obtain blood; this is regarded as a less secret practice.

'jerabuta or 'kandi 'jerabuta, circumcision knife; traded from the North.

'tjaŋari, nether stone of any pair used in milling or food pounding; also any stone used as a working bench, hearth stone, or ironing stone in the preparation of *Triodia* resin.

'miri, hammer stone.

'miri, licking stone, a special type of millstone used in the crushing of oily seeds from the surface of which the bruised food is then licked. From its mode of use it develops special angular polished facets.

Four principal sources exist for the raw materials of these implements:

(*a*) Stone mines or quarries.

(*b*) Detrital flakes resulting from insolation or frost shattering of suitable siliceous rocks.

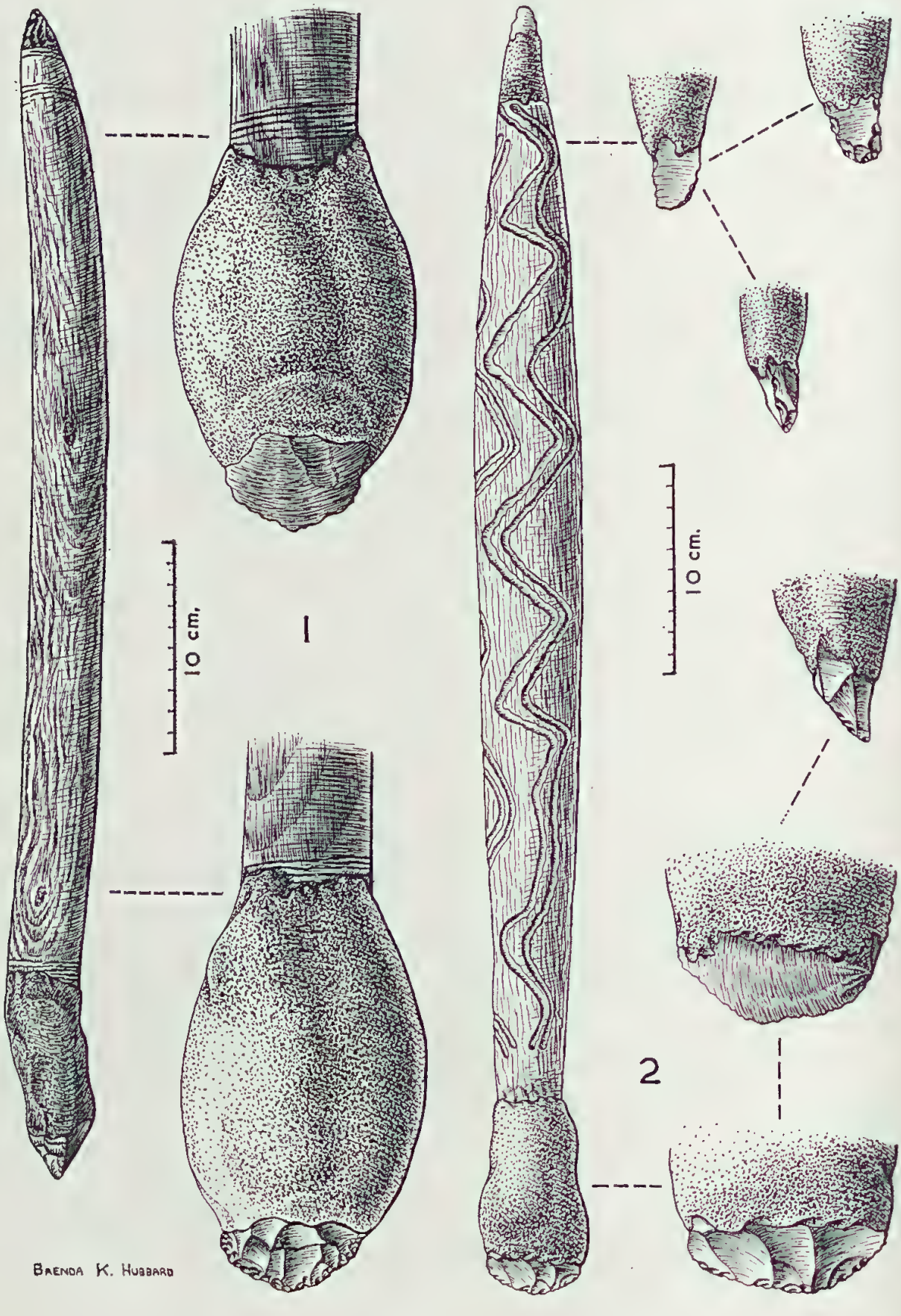
(*c*) Boulders and pebbles in creek deposits.

(*d*) Obsidian of meteoric origin (native name ['mapunba] in the Ngadadjara tribe).

FIELD WORK AT KUDJUNTARI

Our first field station was on the plain south-east of Gill Pinnacle, about a mile from the pool at the base of a waterfall, native name Kudjuntari, at the eastern end of the Rawlinson Ranges (24° 54′ S. Lat. x 128° 50′ E. Long.). We were with a party of about twenty-five nomadic Ngadadjara people, including a family from the Victoria Desert area west of Lake Christopher. Other folk arrived from the country north of the Western Petermann Ranges the day after we appeared, having been driven south by lack of water in that direction; the early summer season had been without rain.

Older men showed us the making of and uses for hafted stone adzes (or chisels), ones mounted with ['keiti] (*Triodia*) resin and placed on the ends of handles they called ['tjuna]. These tools are termed ['kandi 'tjuna], occasionally ['tjunakandi].


10 cm.
1
10 cm.
2
Brenda K. Hubbard

Cutting blades for most of these adzes were insolation flakes found among the detrital rocks in creek beds running down from the mountains. A few randomly struck flakes of a dark grey rock, seemingly igneous, were brought in by one man and used as cutting blades on several chisels that were made while we were at Kudjuntari. He told us he had obtained them at a mine. Unfortunately it was not possible to visit the place but it was described to us as west of Kudjuntari waterhole. The rock there is called ['makurakandi], and is said to be the possession of the males of a species of bandicoot ['makura], of which the females are known as ['walilja]. An elaborate myth was recorded about the ['walilja].

Fig. 1 shows three views of a hafted adze or chisel, as made and used by Tjupurula (his male class name), a man of about 60 years of age of the country west of Lake Christopher on the western border of Ngadadjara territory. He picked up the stone for this ['tjuna 'kandi] as a random flake of opaline silica at ['Patupiri], Kathleen Range, while engaged in a kangaroo hunt on the 7th November 1963. The following day he made the ['tjuna] handle from ['kurara] = ['wakalbuka], a kind of ironwood (*Acacia*). He had sent his wife the same morning to the southern slopes of Gill Pinnacle to gather *Triodia* grass resin for the haft. The ['tjuna] had on it lines incised by running the edge of a stone flake ['kandi] around the ends of the shaft. These lines are called ['ŋamiri] and on tools, and particularly on spears, they serve as identification marks.

When found as a natural flake, to be hafted on this implement, it was discoidal in shape. I saw it before it was hafted into the ['keiti]. There was no delicate trimming on its cutting margin when first inserted in the resin, but shortly afterwards during use in the making of the handle for a further chisel, it was sharpened. In doing this the cutting edge was tapped, using the rounded surface of one end of the second handle which Tjupurula was shaping with its aid. This single act of resharpening resulted in the appearance on the chisel edge of a regular series of tiny semi-circular stepped flake scars. It should be noted that even before this sharpening, the edge which met the wood, was slightly convex and took off a very neat

Fig. 1-2. Hafted adzes or chisels ['kandi 'tjuna].

Fig. 1. Ngadadjara tribe example made by Tjupurula of Lake Christopher area (specimen No. A.54726 in S. Austr. Museum).

Fig. 2. Nakako tribe example made and engraved with ['karo] or "creek" designs, by Tjibukudu of Mamutjara (A.54764). (Scales to be read in centimeters.)

smooth shaving. Some archaeologists may not appreciate that the test for a good chisel edge is the sighting of it in the plane at which the stone meets the work, and that the native craftsman holds his chisel up to eye level in this plane to check on its suitability. This is a better test for a good native chisel than any other.

During the sharpening process Tjupurula did not remove the stone from its setting in the resin. Among the Walpiri, at Yuendumu, skilled old men often remove the stone from the resin and reset it at right angles to the cutting position, before they tap off their sharpening flakes. This is considered particularly necessary when drastic resharpening is desirable; less so when only minor retouch is required. Among the Walpiri the sharpening is often done with taps from the flat face of a hunting boomerang. Such weapons are unknown in the Ngadadjara territory. The removal of trimming flakes in this manner tends to give the profile of the well sharpened stone, in section normal to the cutting edge, an outline which is concave; a similar silhouette to that of a hollow-ground razor.

Several other Ngadadjara ['kandi 'tjuna] were made during our stay and are now in the South Australian Museum collection. The technical processes involved in making them were filmed in 16 mm Kodachrome.

At Mount Davies also both Pitjandjara and Nakako men were found to possess and use ['kandi 'tjuna]. Fig. 2 shows seven views of a double-ended one (specimen A.54764) made by Tjibukudu, a man of about 55 years of age of the Nakako tribe. This man was born at Mamutjara, a water south-west of Bell Rock Range in Western Australia and he was over 50 years of age when he saw his first white man.

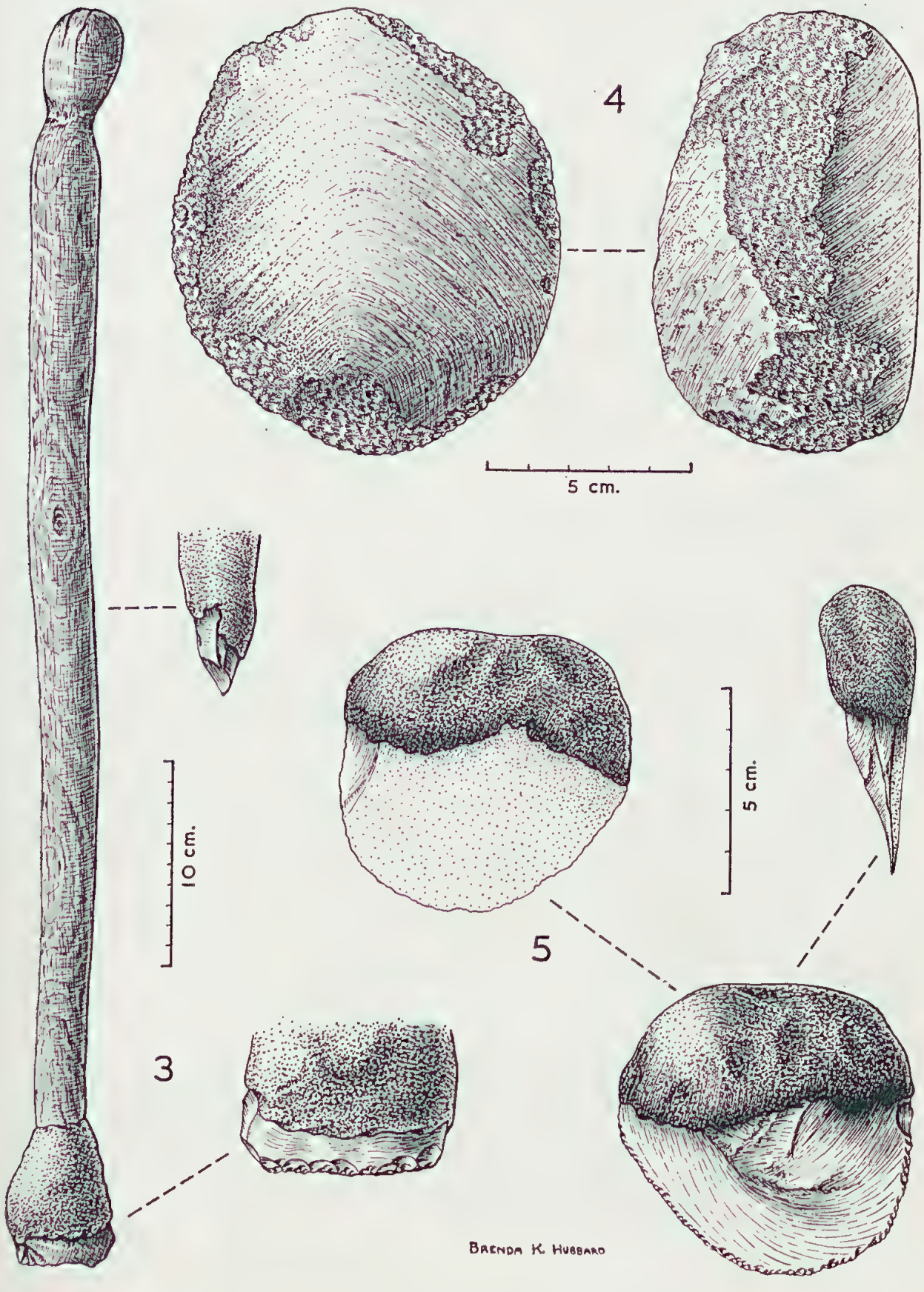
The designs on the handle made by Tjibukudu represent ['karo] or creeks. They had been cut by him in two stages; first he had marked them with a stone flake, using the technique of rocking the tool from side to side to lift off slivers of wood. The design had then been more deeply incised with an engraver of stone, similar to that

Fig. 3-5.

Fig. 3. ['Kandi 'tjuna], Pitjandjara tribe, made by Malutjukurupa, three views (A.54758).

Fig. 4. ['Miri] or "licking stone" used by Malutjukurupa as a hammer at Pulanj pulanj native mine, two views (A.54484).

Fig. 5. Pitjandjara tribe knife, called ['tjimari], made by Malutjukurupa at Mt. Davies ['Malupiti] and sharpened by the "rolling pressure" technique (A.54734).


4
5 cm.
10 cm.
5 cm.
5
3
BRENDA K. HUBBARD

at one end of the present tool. It should be noted that giant carpet snakes, called ['leiru], or ['leiro] are associated in native mind with permanent waters and creeks and the ['karo] design therefore is one also called ['leiru 'walka], *i.e.*, snake mark.

The principal ['kandi] stone of the Tjubukudu implement was a random flake which had had some large secondary flakes removed from it before it was hafted. An adventitious flake scar can be seen on one margin. The engraving tool at the opposite end appears to have been a thin ['kandi] flake which had already been used and had been "worn" by re-chipping on two margins. However it might have been made for the purpose; there was no opportunity to enquire and unfortunately the hafting of it was not witnessed. Before being given to the author this specimen was freshly ruddled by the owner. The use of red ochre in this manner is an almost invariable practice among Desert aborigines, especially when they have only lately come into contact with Europeans. It is a normal custom whenever weapons and implements are given in trade or as gifts such as are passed from one to another during arrangements for marriage, etc.

Fig. 3 gives three views of a Pitjandjara adze or chisel made by Malutjukurupa at Mount Davies. This ['kandi 'tjuna], (now A.54758) has a knob at one end. This swelling facilitates its being carried tucked under a hairstring belt; in addition to its uses as a chisel or adze it may be thrown as a club. Again the ['kandi] was a random flake, one of those struck off at the Pulanj-pulanj mine (described in later paragraphs) and it had been trimmed to a cutting edge, using a small hammerstone no more than two inches long, after it had been set in the resin of the handle. There is a casually developed striking platform at one end of the cutting edge but this does not possess a regular symmetry such as is characteristic of the ['tula], which is a truly knapped implement of peoples living further east in Australia. Because it possesses this platform, however irregular and adventitious, some may consider it to be a borderline or "transitional" example. Pitjandjara men live nearest to the Lake Eyre Basin area and sometimes obtain ['tula] type implements from their eastern neighbours, so they are aware of such implements.

Mr. P. Aitken recently picked up 200 archaeological stone implements on a lately occupied site near Tallaringa, east of the present border of Pitjandjara territory. There was no local implement mine, all the utilized stone being imported material. Ninety per cent of the adze stones were ['tula]; all but two very worn, and all were

of the milky white opaline silica of the Stuart Range country to the east; the rest were ['kandi], all on random flakes of jasperoid chalcedony typical of the country far to the west. There was in addition one flake of the type of stone found at Eucla.

There are three hafted adzes of ['kandi]-stone-bearing type from Nannine, Western Australia, in the Leipzig Museum (their Nos. Au 240, 241, and 238). They were collected by a Mr. Streich. I saw them and made the following notes in 1936. The last numbered one has a small knob at one end of the shaft much as in the specimen figured here from Mount Davies.

Each of the handles of the Nannine specimens is longitudinally grooved with many rather continuous shallowly engraved lines 0.3 cm in diameter. Au 240 is grooved for the whole visible length of the wood; this specimen is 84.5 cm long, the length of resin haft being 8.0 cm and there is 0.5 cm of visible stone. The general diameter of the handle is 2.4 cm and the shaft is very slightly curved. The cutting edge is transverse and straight with secondary trimming on the stone. The other two specimens are shorter, 75.5 and 74.0 cm in length with about 10 cm of the stone-bearing end not longitudinally grooved. The cutting edges are convex and have been secondarily trimmed, evidently while in the haft. At the best cutting angle all three of these chisels present a smooth and slightly convex cutting edge to the work surface.

There are several dozen other hafted specimens of this ['kandi 'tjuna] type in the South Australian Museum collection and their distribution ranges from near the Western Australian coast, as far east as the Western MacDonnell Ranges and the Musgrave Ranges.

NATIVE MINE AT PULANJ-PULANJ

On 13 November 1963 we were able to see aborigines gathering stone for implements at one of their mines. Several of them went with us to the quarrying site, including three Nakako and one Pitjandjara man. Malutjukurupa, the Pitjandjara, took along a ['miri], "licking stone", as a hammer, it weighed 33oz. (fig. 4). Tjibukudu the old Nakako individual relied chiefly on blocks of matrix when rough-trimming the more desirable pieces he obtained.

Ten miles south of our camp at Malupiti on the plain west of Mount Davies there is a creek, not yet named on official maps, which flows south-eastward out of the Tomkinson Ranges. The mine outcrop is situated in Pitjandjara territory close to their western border with the Nakako, whose country begins near Bell Rock Range. There is a roughly horizontal bed of white chalcedonic silica exposed on both banks and in the bed of the creek, at the native place known as ['Pulanj 'pulanj]. The approximate position is 26° 19′ S. Lat. x 129° 8′ E. Long. It is considered an important local source of stone for implements. There are said to be similar outcrops near Bell Rock Range in Nakako territory.

On arrival at Pulanj-pulanj two of the younger men pried out slabs and fractured boulders of the siliceous rock up to two feet in diameter from the red earth covered walls of the dry creek. Boulders lying in the open were considered to be not suitable for attention. The largest boulders they could lift they raised high above their heads and hurled down on to the rocky pavement, attempting to shatter them into smaller pieces. They endeavoured to stand on more elevated places, seemingly both to increase the effect of their throws and to escape flying splinters of silica.

Smaller pieces were then struck, virtually at random, either with the abovementioned hammer stone, which was passed from hand to hand as required, or with a piece of the mother rock. When a suitable-sized flake was detached by the hit-and-miss process, it was set to one side. When a boulder of particularly good stone was discovered it was alternatively hurled down and struck at with the hammer until no further flakes could be obtained from the core which remained. A sample core, at a stage when rejected, was a subspherical mass seven inches in diameter, weighing 248oz. (specimen A.54731 in the South Australian Museum).

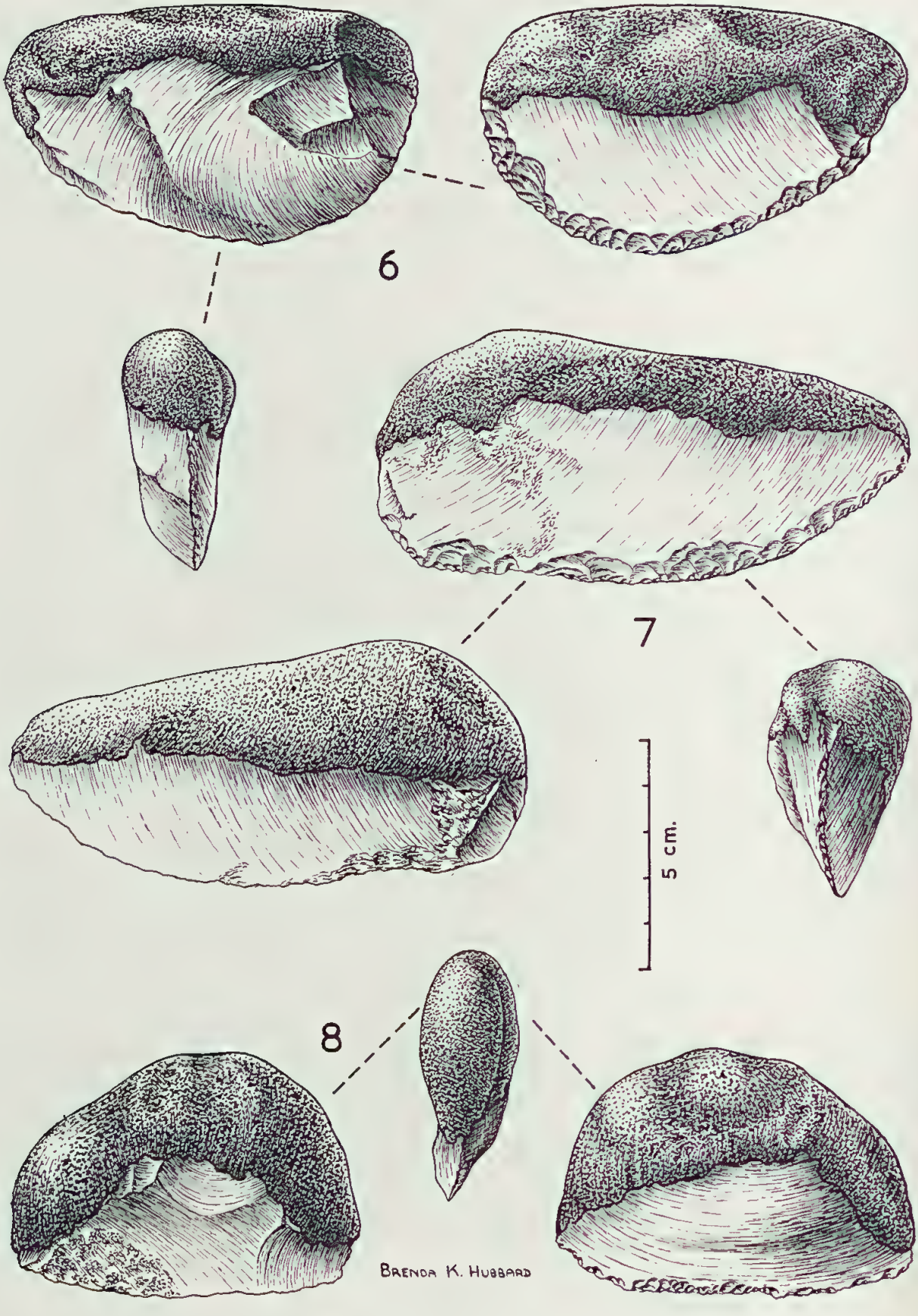
The aim of the knappers seemed to be to obtain flakes from which they could fashion subrectangular pieces with one thick obtuse longitudinal margin, destined to be the back, and a thinner opposite margin, the potential cutting edge of the implement.

Useful-seeming flakes, however irregular in shape at first, were set aside until quite a series had accumulated. Then, using the hammer, rough trimming was done on the best of them. Well over two-thirds of the flakes were discarded in this phase of trimming.

The ones set aside for further development tended to be semi-circular in outline; they were short blades measuring three to four inches along one axis and one-and-a-half to three on the other and from one-half to three-quarters of an inch in thickness. A few had remains of a striking platform along the straighter and thicker side but in general there were few indications of intentionally developed or planned striking platforms; indeed the flakes had been detached from the matrix in a variety of random ways. Each man carried back to the camp between a dozen and twenty pieces; these were chosen from his second pile of better-shaped flakes during a final selection.

Viewed as a potential archaeological find, the researcher of the future, if he discovered this mining area, after it had been used for the first time would see the remains of a series of about 20 large boulders up to a foot in diameter which had been broken into several pieces and then abandoned. Half a dozen further boulders would be found broken down into many smaller irregular pieces. Lying nearby there would be a subspherical core-like block or two. From such cores it would be difficult, perhaps, to break off any further smaller pieces. This kind of core would be lying among a variety of pieces of broken stone. Nearby he would find a series of perhaps 50 or more sub-rectangular flakes. He would note that most of those of the general dimensions of about four by two inches (10 cm x 5 cm) were absent. There would be an abundance of small chippings. Finally nearby he would find a dozen or more flakes, roughly of the order of two by four inches, with a tendency to possess one blunt, thick margin and a sharper somewhat more arcuate one opposite. He would not find any worked flakes. He would see bruise scars on nearby rock surfaces and perhaps would find a hammer stone with which knapping work had been done (in the present instance one core, the hammer and some discarded flakes were retrieved by the observer, but only after it was clear that they were going to be left behind).

Unfortunately for the future archaeologist, the site we visited had been worked over many times in the past. Some parts of it had been subject to flooding and other earlier workings either had been disturbed or washed away. Where earlier men had chosen higher parts of the bank as workshop area their successive efforts had led to the strewing about of an entirely confusing mass of debris of all kinds.


6
7
5 cm.
8
BRENDA K. HUBBARD

The white implement stone of Pulanj-pulanj and its vicinity is called ['kandi 'teilka] and its origin is ascribed, in Pitjandjara tradition, to a partly initiated ancestral Being, called 'Minu, who lived at Mount Davies. This man detected ring-necked parrot men ['Padilka 'wati], eating the food of his country and attacked them. He caused hailstones to rain down and when they were maimed by the icy missiles he used his ['winda] or heavy wooden javelin to stab and kill the injured ring-necked parrot men. The home of Minu was on the Mount Davies Range, at Windalka; this is a hill to the south of the plain at Malupiti lately used as an airplane landing field, and near where we were camped. The term ['minu] is applied to all men who have been circumcised, but have not yet been subjected to the later rite of subincision. In Ngadadjara stories Padilka men were the bringers of the rite of subincision and they arrived from the north.

WESTERN DESERT HAFTED KNIFE

The word ['tjimari] was spoken by a Ngadadjara man in a text being recorded on tape at Gill Pinnacle. This was a first appreciated clue that the same form of knife used among the Mangala and others of the Desert south-east of Broome, and there known as ['jimari], might be known also among the Ngadadjara.

Very soon thereafter we transferred to our second field station west of Mount Davies in South Australia (26° 10′ S. Lat. x 129° 8′ E. Long.) where we found Nakako and Pitjandjara men who were familiar with the manufacture and use of these knives. They offered to take us to their mining place at Pulanj-pulanj, as described in the previous section of this paper.

It soon became evident that knowledge of this type of knife, known to the Nakako by the same term ['tjimari], was widespread in the Western Desert, and I discovered that during the 1935 Expedition to the Warburton Ranges I had already heard and published a Ngadadjara term ['japu 'tjimari] with a meaning of "stone used for cutting", but had not then realized its true significance. ['Japu] or ['jabu] means "stone".

Fig. 6-8. Knives called ['tjimari].

Fig. 6. Pitjandjara example made by Malutjukurupa at Malupiti of stone from Pulanj pulanj, three views (A.54735).

Fig. 7. Nakako example made by Tjibukudu, of Mamutjara, three views (A.54738).

Fig. 8. Another example, Pitjandjara, made by Malutjukurupa, three views (A.54739).

I had already described and figured specimens (Tindale, 1957, p. 13, 2a-e), of the Mangala knife or ['jimari], had referred to and figured a somewhat similar specimen made by a Pintubi man of the country west of the MacDonnell Ranges, and had spoken of others used by Njangamarda, Njamal, Bailgu, Wanman and Indjibandi tribespeople. I had also proposed the term *jimari* for use by archaeologists in referring to archaeological examples of the type, such as are found in the Tartangan horizons of Eastern Australia (Tindale, 1957, two papers).

In my notebook I found recently also notes and sketches of a specimen (D2690) in the Peabody Museum, Harvard, of typical *jimari* form; it is a random flake made from pale translucent siliceous rock, 6.6 cm in transverse diameter and 5.3 cm high of which 3.8 cm is masked by *Triodia* resin. According to their records it had been collected by E. Clement in 1926, from a member of the "Qualluana" (*sic*) *i.e.* the Ngaluma tribe; I presume their rendering is a misreading of the incorrect version Gnalluma which I have elsewhere seen ascribed to Clement.

Many, if not all of the hoard of large flakes described by Tindale and Noone (1941) from Eucla now seem to me, after critical re-examination, to have been intended for hafting in the manner of Nakako and Pitjandjara ['tjimari]. The existence of a possible trade route running in that direction is implied by a Nakako myth and song cycle (recorded on tape) which describes how Kite-hawk Beings called ['paniŋka] had saved fire for mankind by rescuing it as it was about to be drowned in the great southern waters by ['keibara], the Turkey Bustard Being. There is a memorial to this great event in an arrangement of painted stones at Mamutjara, which I saw during a brief journey down into Nakako territory with Mr. W. B. MacDougall during our stay at Mount Davies, and lengthy tapes recording a Ngalea version of a similar song cycle were made more recently at Yalata in October 1964. The Keibara song series is associated with the flint gathering place at the western end of Wilson Bluff, east of Eucla.

It was possible to observe and film the making of ['tjimari] by both Pitjandjara and Nakako men. The Pitjandjara individual Malutjukurupa prepared several examples. Fig. 5, 6 and 8 depict ones he made on 14 November 1963 from his stock of flakes obtained at Pulanj-pulanj. His equipment included a hearth stone, a small subspherical stone hammer (A.54825) of gneissic rock weighing 11oz., and

several adventitiously present smaller angular stones which played minor parts as temporary hammers in trimming. With the hammer he struck the blunt back-edges of the flakes to trim them to shape. These roughly trimmed "backs" were then covered over with *Triodia* resin so that only the future cutting edge remained exposed. The first knife he made (fig. 5) required little secondary work because the primary flake was already thin and sharp. Delicate edge trimming by rolling the smooth face of the hammer against the margin was sufficient to prepare the cutting edge.

The second example, fig. 6, was a thicker flake. The back required little treatment, but the planned convex cutting margin needed many trimming blows, more than 25 successive strikes with the hammer being necessary. These produced a rather evenly spaced series of scars and gave a semicircular outline to the cutting edge. Once the desired shape was achieved by this trimming Malutjukurupa struck off a series of very carefully spaced smaller flakes working from the ends towards the middle of the knife blade. His blows were struck obliquely and directed slightly away from the central point of the semicircular knife edge. After covering the roughly-shaped back with *Triodia* resin he critically examined the planned cutting edge, then pressed the smooth surface of the hammer stone against it with a rocking motion and pressed off a few small tertiary flakes.

All completed knives were painted over with a dull-coloured red ochre mixed with water.

We learned that ['tjimari] should be kept wrapped up in eagle down or underfeathers; several knives may be kept together and made up into a package bound around with human hair string.

The old Nakako man Tjibukudu made the ['tjimari] knife shown in fig. 7 as one of several fashioned from the random flakes he had brought back from Pulanj-pulanj. He made preparations to haft and trim two of these knives on the afternoon of our return from the mine but was out of *Triodia* resin. By the following morning he had acquired an additional supply of ['keiti] and finished the placing of resin along the roughly-trimmed back of the figured specimen (now A.54738). In the field I had made an assessment that this flake had been detached from a natural cleavage face of the stone but closer examination suggests that it is more likely to have been made from a piece taken from an old flake scar surface. The resin handle was placed on the stone before any real secondary trimming of the

proposed cutting edge was attempted and it seemed it might be ready for use without further effort. However, after looking at it, he elected to trim it by striking at it with his hammer along most of the exposed cutting edge. Strong blows were directed first at the middle of the length of the knife edge, thus bringing into better shape the semi-circular profile of the knife edge. His trimming method was less systematic than was that of Malutjukurupa and his rule seemed to be to hit successively at the highest projecting points until he had achieved the desired symmetrical profile. He avoided striking off flakes from that part of the edge where there was previous flaking, in the form of "natural" scars; as it happened these were on the opposite side of the margin. The final pressure flaking was then executed by rolling a stone against the edge.

This work was done on the 14th November. There was a shortage of [ˈkeiti] in the camp. At the request of several men we made a visit to Wingelina, about 20 miles away, using a four-wheel drive vehicle, over rough country, to the nearest point where good [ˈkeiti]

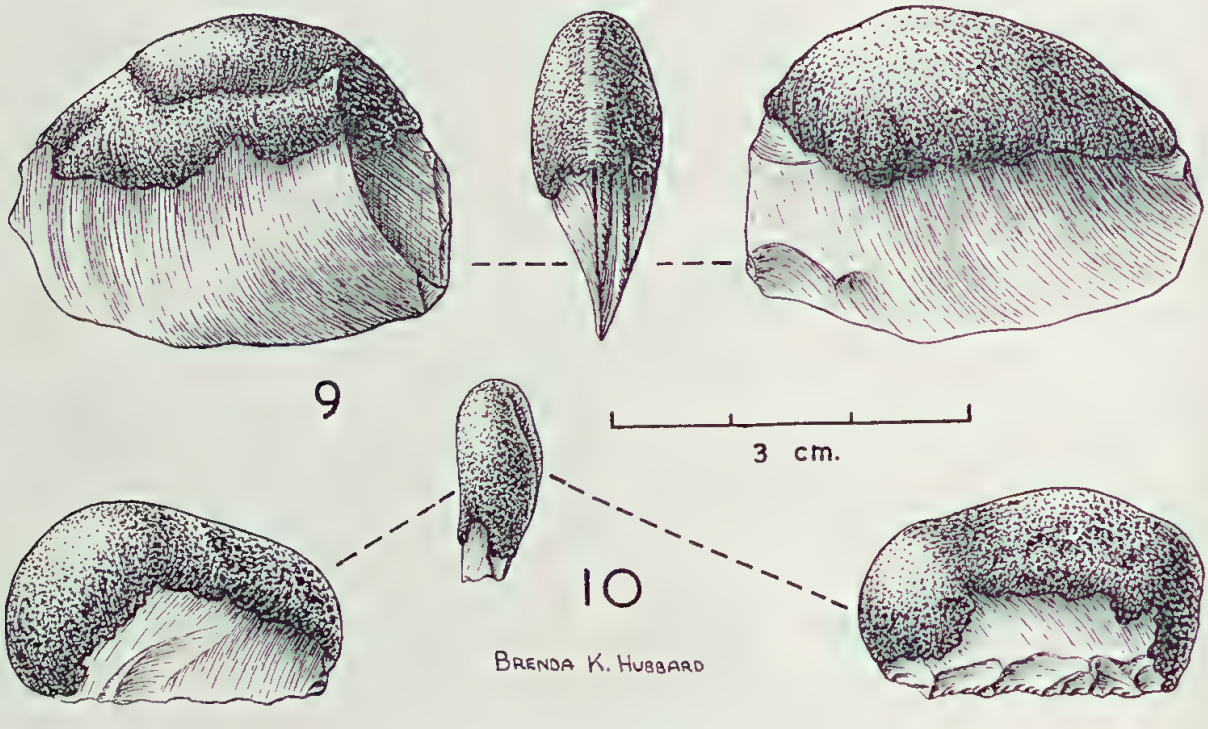


Fig. 9-10. Small knives.

Fig. 9. Example of Pitjandjara [ˈkandi] without secondary work, made and used during circumcision rites witnessed at Konapandi, Musgrave Ranges, on 23 June 1933 (A.21645).

Fig. 10. Pitjandjara example of [ˈkandi] made and used by Malutjukurupa; handle of *Triodia* resin (A.54740).

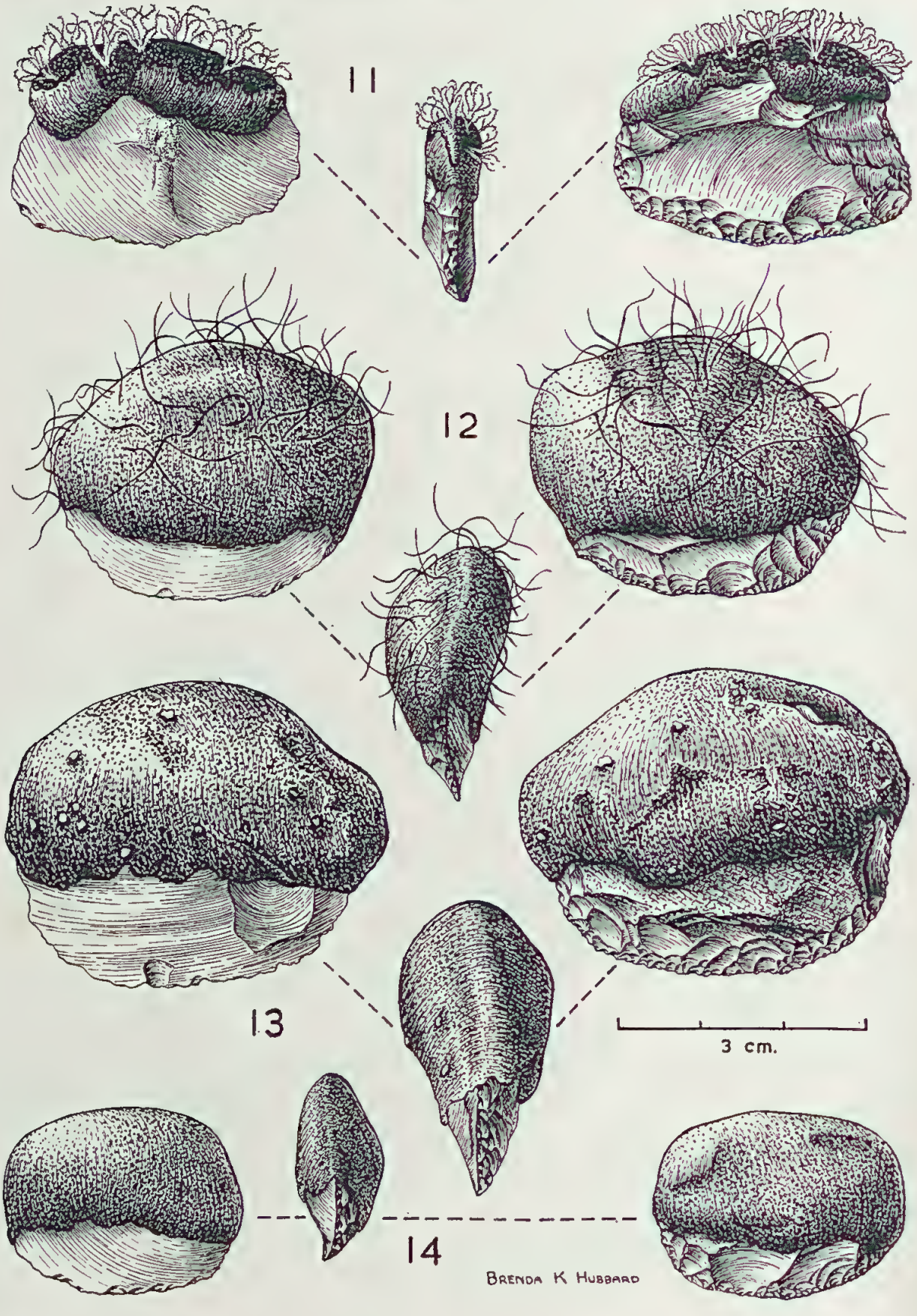
resin was obtainable. At this place the process of *Triodia* resin-gathering was witnessed and filmed. Piles of *Triodia* grass were placed on an area of hard flat termite mound and beaten with sticks. The resinous dust was gathered, melted with a cool fire of strips of burning mallee bark held over the dust, gathered up on stick handles and compressed into cakes using hot stones as irons.

Some men who went part way with us on the journey gathered white opaline silica implement stone at Wingelina and from these further implements were made on other days of our stay at Mount Davies.

SMALL KNIVES

Ngadadjara, Nakako and Pitjandjara men all wear their hair tied up in a chignon (although this fashion is fast falling into disuse). Often they carry, tucked into their hair bindings of kangaroo fur string, one or more gum-hafted small flakes ['kandi], (fig. 9). The resin hafts sometimes have hair or fur fibres clinging to or melted into their surfaces. These 'kandi they use as general purpose tools, also as spares for placing on the handles of their ['meru] or spearthrowers.

The Wingelina flakes were all rather small and suitable chiefly for the making of saw-like knives and small knives of this kind. When new they are merely selected primary flakes, with a handle of ['keiti]. This resin is placed on the potentially less attractive margin and covers from one-third to one-half of the edge of the stone. By the time it is discarded after much use and resharpening the stone has assumed a familiar archaeological form loosely described as a "scraper" or "adze stone" but usually it is not used up to the point where it assumes the "burren adze" form because such a form requires it to have been used as a hafted chisel or spearthrower cutting tool and reversed in setting as illustrated in fig. 19. Fig. 10 shows such a ['kandi] made by Malutjukurupa from one of the larger pieces of Wingelina stone, used, and resharpened. Straight-margined knives like it are used in making ['ŋamiri] lines and similar marks on spear shafts. When the edges are trimmed so that they are serrated, they serve very efficiently as saws. Fig. 11-14 show various other hafted specimens from the South Australian Museum collection. They were obtained in Western Australia.


11
12
13
14
3 cm.
Brenda K Hubbard

When blunted by use the resharpening of these originally simple flakes is done in one of several ways:—

(*a*) By striking with another stone.

(*b*) Striking with a piece of hardwood.

(*c*) Pressing with a hardwood edge either to make a continuous cutting margin or at intervals along the edge to make a saw-like one.

(*d*) Pressing on the edge with a smooth stone, using a slightly rolling motion to fashion a very delicate series of tiny pressed-off flakes.

(*e*) Pressure-flaking by nibbling the edge with the teeth and spitting out the detached pieces.

The smaller and more delicate the tool the more likely that it will be pressed rather than struck. All the above methods of resharpening are known to Nakako men.

The making of such small gum-hafted knives is widespread. In 1938 a Tjapukai man at Mona Mona, on the Atherton Tableland, Queensland, took a small core of milky quartz rock (fig. 15) and struck off several flakes which he hafted with beeswax. Fig. 16 illustrates one example. Such quartz knives were then still being used in the cutting of body cicatrices. Their name is ['ba:bulai]. He demonstrated only the one method of sharpening, that of striking the edge with a hammerstone.

Archaeological examples have been found. Fig. 17 illustrates a recently discarded example found lying in a camp a quarter of a mile from Erliwanyawanya, Musgrave Ranges, in 1933.

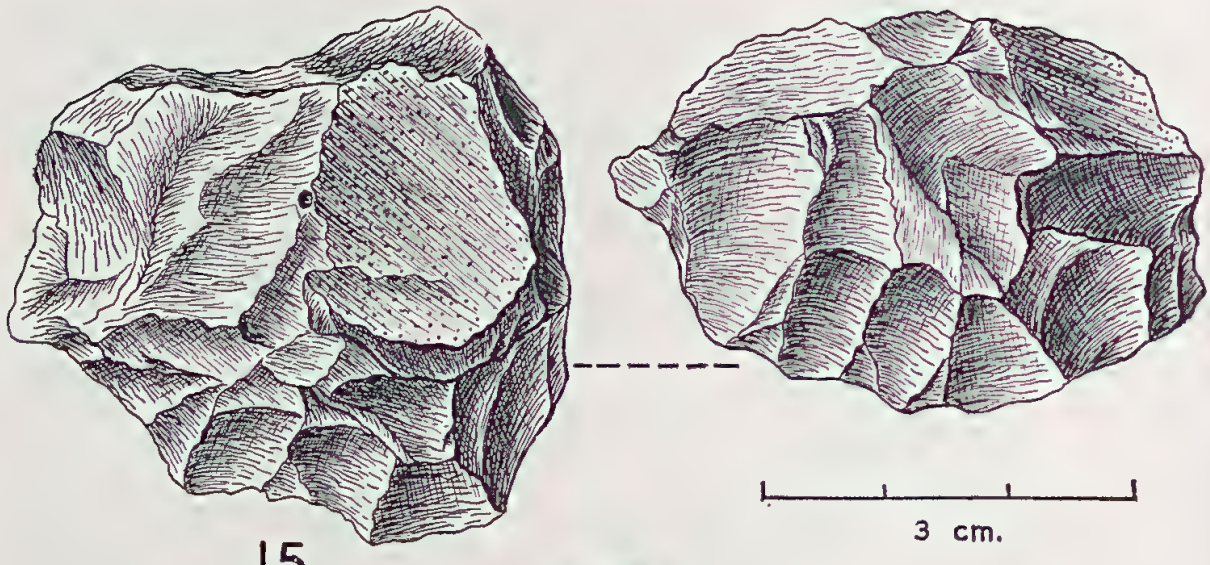
Fig. 11-14. Small resin-hafted knives.

Fig. 11. Retrimmed example with decoration of eagle down set in *Triodia* resin, Kalgoorlie area, Cook collection (A.37212).

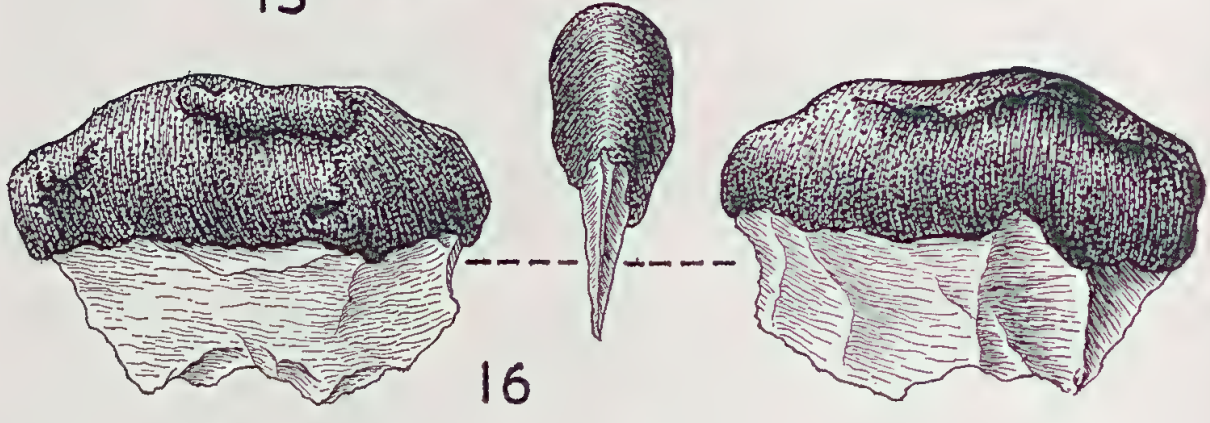
Fig. 12. Circumcision knife ['kandamu] with human hair incorporated in resin handle, Bailgu tribe, Upper Fortescue River, W. Australia; stone is from native mine at ['Tambaða], a spring on Tambrey Station; this stone has a reputation for allowing quick healing of wounds (A.45159).

Fig. 13. Circumcision knife of Indjibandi tribe, Lower Fortescue River, also of Tambatha stone; used near Roebourne during the initiations of December 1952 (A.45160).

Fig. 14. Circumcision knife of Pandjima tribe, Hamersley Ranges, W. Australia; their name ['kandi]; held with the chipped face upwards when in use (A.45111).

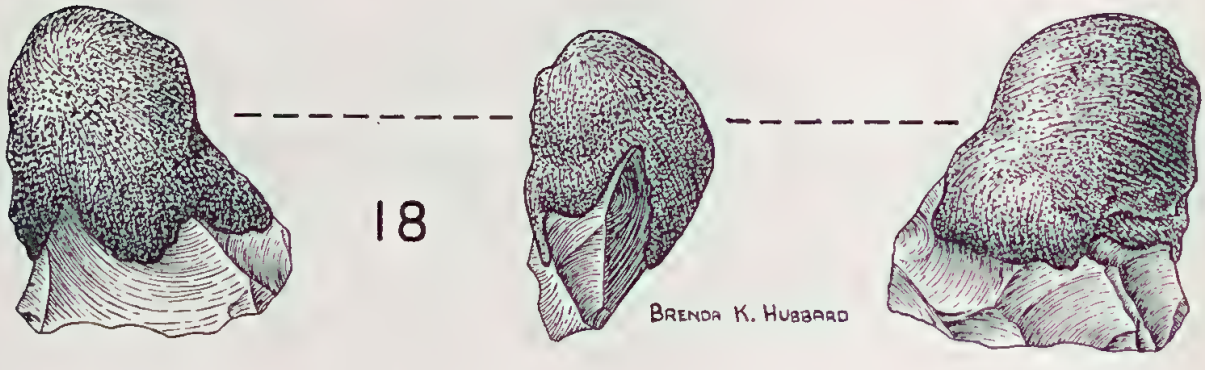


15



16

17



18

Mr. Paul Lawson of the South Australian Museum staff, placed his hand in a small hole in the cliff wall above an aboriginal rock shelter at Mypolonga on the River Murray. Sifting through the dust with his fingers he recovered two crude resin-hafted flakes, one of flint of the type found in the South-East of South Australia and the other of Mount Lofty Range quartz rock. These archaeological examples were made at an unknown date in the recent past. The floor of this shelter contained only debris of the latest or Murundian culture phase. They indicate knowledge of the use of such simple tool flakes as far south as the vicinity of the Murray River mouth. Neither of the Mypolonga examples showed secondary working and if they had been without resin hafts would have been ignored, as "waste flakes", by the archaeologist. Our knowledge of them in the living culture warrants us regarding them as prepared but as yet unused small knife flakes. Fig. 18 illustrates the flint example; the quartz one is so similar to the present-day Queensland example (fig. 16) as not to require a separate illustration.

Quartz flakes showing few signs of secondary working but with the edges dulled as if by use are found frequently on late archaeological sites in South Australia. Often they are ignored by those who are interested in collecting stone implements. It is possible that these were hafted in like manner with resin, although until after this paragraph had been drafted no specimen had been found with such a handle other than the abovementioned Mypolonga one. A further example is now known from Mootwingee, New South Wales (A.55221), found with adhering remains of the hafting resin.

According to Angas (1847, i, p. 111) the Pangkala of the country north of Port Lincoln "scraped [their spears] to a sharp point with pieces of quartz". Their spears were similar to those of Western Desert peoples such as the Pitjandjara. They had composite shafts with a single curved barb of hardwood, lashed to the wooden spear tip with kangaroo sinews. An indication that the Pangkala scraper

Fig. 15-18.

Fig. 15. Milky quartz core from which knife flakes were struck, Monamona, Queensland, Tjapukai tribe (A.27404).

Fig. 16. Quartz knife flake, called ['ba:bulai], from above core; hafted with native beeswax; used in cutting cicatrices (A.27405).

Fig. 17. Archaeological ['kandi]-type flake found in a late camp, Erliwanyawanya, Musgrave Ranges, 1933 (A.21602).

Fig. 18. One of two hafted flakes found in a hole in the cliff wall at Mypolonga, River Murray, South Australia (A.42486).

was not the adze knife implement found on the spearthrower of the Western Desert tribes is given by the fact that the Pangkala spear-thrower is entirely without the grass tree resin knob on the handle such as is found on those used by tribes north and north-west of Spencer Gulf.

According to Angas quartz flakes also were used by the Pangkala for the cutting of deep cicatrices such as they, and the Wirangu to the west (personal observation) incised on the backs of their men in the final stage of initiation, called ['Wiljalkanje]. At a specific stage in the proceedings the "sponsors" of those to be operated on (in the Wirangu the potential wife's father and persons called by the same kinship term) "sharpened" their pieces of quartz. The principal operator made a deep incision in the nape of the neck, then cut broad gashes from the shoulder to the hip down each side, making each groove about an inch beyond the next.

The Nan:a and Ngadadjara during their subincision rites, which I witnessed in 1935, used simple flakes of a jasperoid rock for the operation. The Nan:a tribespeople who took part then had just made their first contact with Europeans, the members of our Expedition. The edges of the simple flakes, used in subincision, if unsuitable as they are, may be trimmed by biting or nibbling the margin, spitting out the tiny waste flakes resulting from tooth pressure on the edge.

These ['kandi 'minu] and others may be seen in course of trimming by biting, and in use in 16 mm cine film No. 39 of the Board for Anthropological Research, University of Adelaide. At a specific stage in the subincision ceremony an old man is seen to walk into the area where preparations are under way for the initiation. He throws a handful of simple flakes on the ground before a circle of men who pick them up, examine them carefully, and trim them by biting with their teeth (tooth-pressure flaking).

The same general type of flake is used whether it be for the primary cutting of the penis along the midline to open up the whole urethral pipe while the victim is held, or to extend the cut towards the base. This takes place in a later operation when young men stand up and offer themselves voluntarily for further cutting. Still older men may trim pieces of flesh from their own urethral cuts as a form of self mutilation using these same ['kandi 'minu].

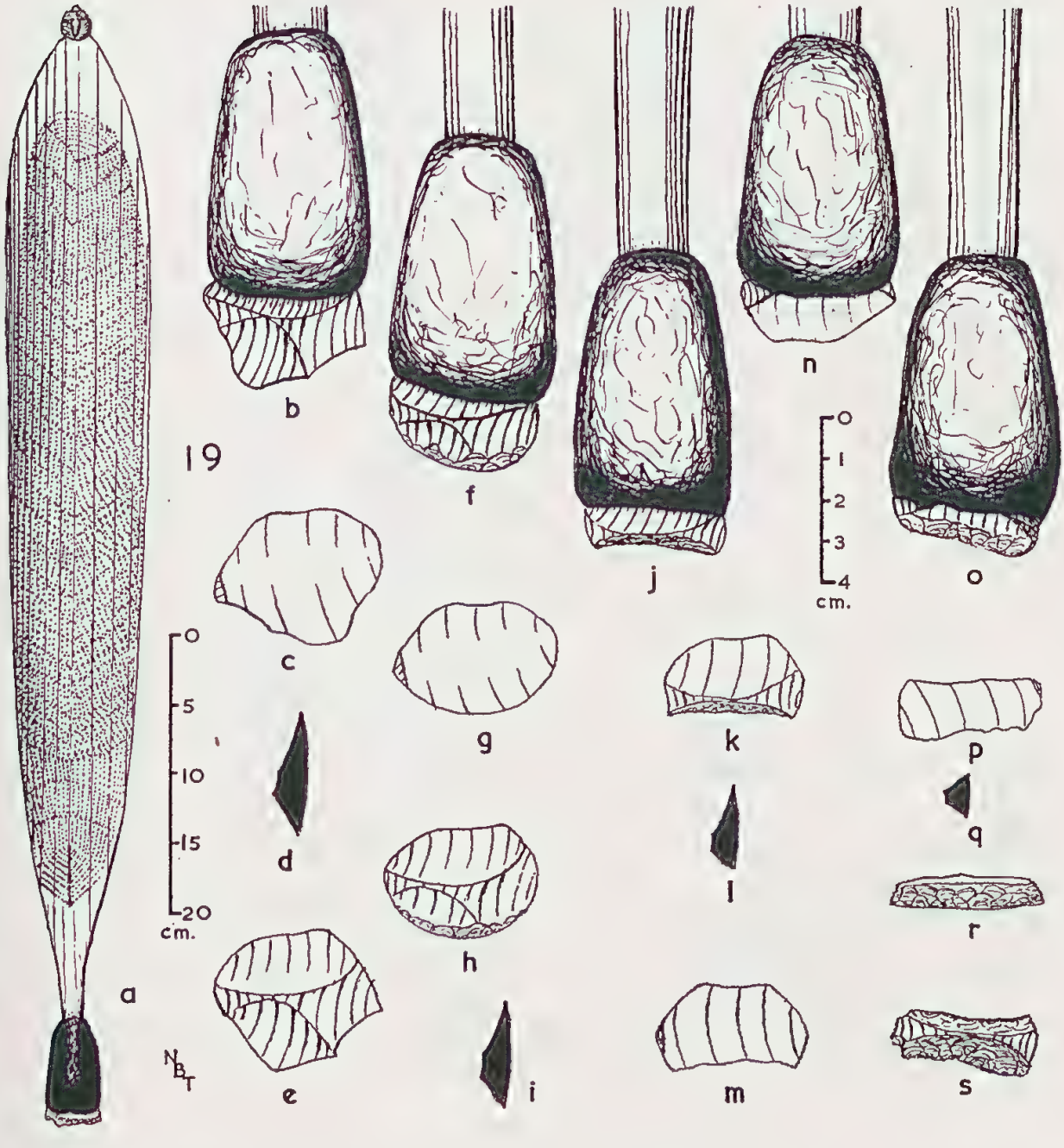


Fig. 19. Observed life of the stone on a spearthrower over two week period. a, Pitjandjara ['meru] with ['kandi] hafted in ['keiti] or *Triodia* resin, Konapandi, Musgrave Ranges, S. Australia, collected by N. B. Tindale, June 1933, length 81 cm. (specimen No. A.21673). b-s, Progressive stages in life of a ['kandi] from this spearthrower when in use in the Mann Ranges. b, Random flake newly inserted in position of use; c-e, two views and cross-section of same; f-i, second day, showing retouch; j-m, seventh day, with cutting edge ineffective through continual resharpening; n, eighth day with stone reversed; o, twelfth day with second margin showing resharpening; p-s, three views and cross-section of a stone at moment of discarding; r, shows the even cutting edge as it meets the work surface. The figures b-s are based on sketches and are therefore slightly diagrammatic.

The use of the ['kandi] flake as a general cutting tool on the handle end of the Western Desert spearthrower ['meru] is well known and all spearthrowers seen on our journey had a mounted stone. Each adult man possessed one and several examples were collected.

The fact that the Western Desert implement flake is a random one, and not a ['tula] is not clearly understood by some. Therefore I have chosen to figure a spearthrower, the use of which I made a point of observing daily over some weeks during a wander tour in the Western Musgraves and Mann Ranges in 1933 with nomadic Pitjandjara aborigines and in company with Dr. C. J. Hackett. In afternoon sessions over a period of about two weeks the spearthrower itself was incised with a design by the owner using an opossum jaw and tooth as engraving tool. During this time a simple flake was inserted in the resin of the handle. It was used, and resharpened, then reversed in position and subjected to further use and resharpening until it assumed the "worn" form of the so-called *burren* adze of the archaeologist. During this time it served all functions required by the owner, in cutting meat, sharpening spears and making new spear shafts. This ['meru] is now specimen A.21673 in the South Australian Museum. The series of drawings is based on sketches made at the time. The birth of such a ['kandi] thus is entirely different from that of a ['tula] of the Lake Eyre Basin.

A ['tula] starts off as a systematically knapped discoidal implement. For confirmation one should read either the eyewitness description by Roth (1904, p. 17) of the manufacture of what he calls a "pot-lid" flake, *i.e.*, the true *tula* of the archaeologist, or examine one of the trade parcels of such pot-lid flakes which have originated at one of the mining places near the Lake Eyre Basin.

CIRCUMCISION KNIFE OF SPECIAL TYPE

Beside the locally made ['kandi] and ['tjimari] knives there is a rare item of trade of which several are possessed by the Ngadadjara. A single one was in the possession of the Nakako man Tjibukudu at Mount Davies. These are ['jerabuta] or ['kandi 'jerabuta], circumcision knives. These are shaped like projectile points of biface type, are pressure flaked, and have a small handle of resin at the butt end. The example which Tjibukudu produced was made from a material very close to the white chalcedonic silica found near Hall Creek in North Western Australia, and it had been fashioned in the exact

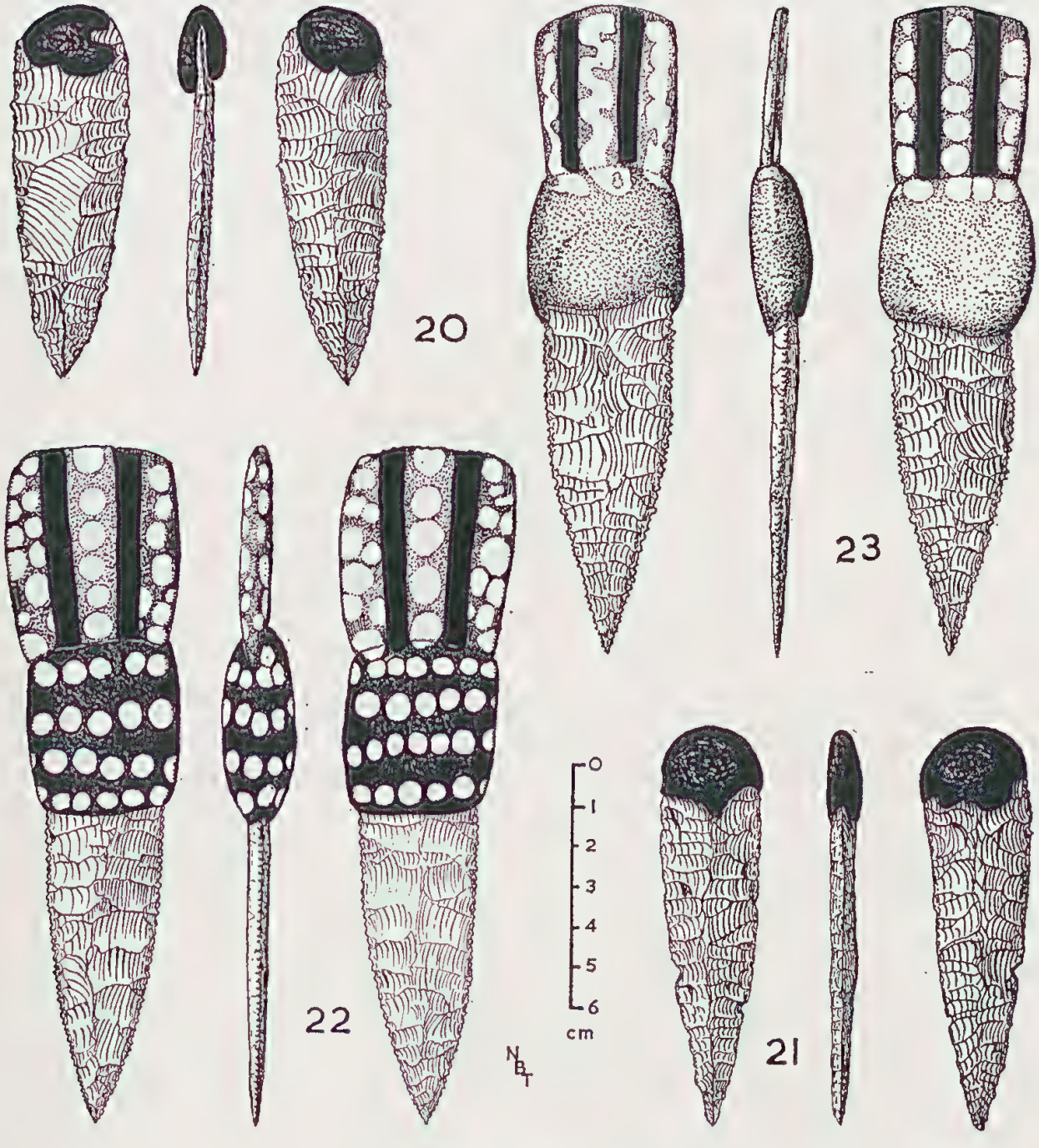


Fig. 20-23. Biface knives.

Fig. 20. Nakako circumcision knife, ['jerabuta], Mt. Davies, S. Australia, traded from the north (specimen A.54730).

Fig. 21. Ngadadjara knife, used in circumcision operations of 24 August 1935, witnessed at Warupuju, Warburton Range, W. Australia (specimen A.22821).

Fig. 22. Circumcision knife with resin haft and wooden handle decorated with ochres and pipeclay, labelled only as from Central Australia (specimen A.35611).

Fig. 23. Knife with resin haft and decorated wooden handle from west of Tennant Creek, Northern Territory (specimen A.42533).

manner of spearheads made for me in 1953 at Moolabulla, North Western Australia, by Kitja and Djaru men. Sixteen mm cine films of the manufacture of the latter are available and were shown to anthropologists in March 1963 at the Australian Institute of Aboriginal Studies Conference on Nomenclature of Implements and Cultures, but await formal publication.

This ['jerabuta], (fig. 20) was the only specimen in the possession of the Nakako people; it had been received by ['Tjibukudu] from ['Modonja], the father of ['Warutju 'tjukurupa], a recently initiated young Nakako man who was also in camp at Mount Davies. It had been used at this young man's initiation, several years previously, before ever they had met white men. The knife had come by trade from the direction of the Warburton Ranges. It was known only as having come ultimately from ['kaieli], *i.e.*, from north or north-west. The specimen is now A.54730 in the South Australian Museum. It seems to be the south-east-most recorded example of this type of traded implement and it must have been transported for at least 600 miles, even if it came by the most direct possible route. Hall Creek is due north of the Nakako tribal territory and separated from it by at least six tribal boundaries.

The mode of use of such ['jerabuta] is clearly depicted in the Board for Anthropological Research 16 mm film No. 38 where two examples of ['jerabuta] may be seen in use during the circumcision operations observed by the writer and his party at Warupuju in the Warburton Ranges in August 1935. Biting of the edge to sharpen it, may be noted as a happening during a critical stage of the operation. Fig. 21 shows one of the two Warburton Range examples (specimen A.22821 in the South Australian Museum).

Wood and resin hafted examples traded from N.W. Australia are known from Central Australia (fig. 22) and from west of Tennant Creek in the Northern Territory (fig. 23) and are treasured specimens in the South Australian Museum. In both these examples the handles are decorated with white spots and black lines on a red ochre background.

TRIMMING TECHNIQUES

The rolling technique of pressure flaking with a smooth pebble which I describe in this paper is an entirely distinct method of stone working which has never been noticed, to my knowledge, by any of those who have sought theoretical ways of working stone.

The implement to be worked by this method is cushioned in the palm of one hand, bulbar face upward, and gripped with the finger tips so that the edge to be worked is cushioned on the pad at the base of the thumb. A rounded, generally smooth flat pebble or similar presser is laid on the bulbar flake surface, rolled towards the margin and pressure is exerted. Tiny flakes are removed by this pressure. These tend to be thin, often markedly semi-circular in shape, with only the pressed edge itself approximately straight. Successions of such flakes are removed, either by working systematically along the edge or more or less at random. The relatively continuous sharpened edge which results tends to be rather straight, much more so than if either a knapping technique or pressure-flaking with a pointed or blunt-ended presser or bone or wood is employed. As compared with the above the pointed presser is applied to a series of points along the edge tending to create a rather serrated margin, each flake scar possessing an obvious negative bulb at the point of pressure.

Because pressure exerted by the rolling technique is likely to be well controlled, flake scars left on the sharpened implement tend to be subequal and to present a uniform line of rather shallow impressions.

Variations occur according to the texture of the implement stone, the thickness of the flake and the individual habits of workers, as exemplified by the differing approaches of Tjibukudu and Malutjukurupa.

Sufficient character seems to be registered by the rolling pressure technique to enable one to detect its utilization whenever found.

I have experimented following the indications of my native teachers. Seemingly point pressure type scars cannot be made using only the rounded surface of a flat pebble or similarly shaped wooden tool, nor have I found it possible to make rolling pressure types scars on flakes using either a knapping hammer or a pointed presser.

The technique was first brought to my notice in 1953 when men were making circumcision knives in the Pilbara district of Western Australia. I briefly mentioned these implements in an earlier paper (Tindale, 1957, p. 15). It was again seen in use at Kudjuntari and in the Tomkinson Ranges as a technique of Nakako, Ngadadjara and Pitjandjara men. The results achieved by this method possess a character so different from any other that it seems to me that it may be detected whenever used. The combination of primary and

secondary knapping with delicate tertiary trimming by stone pressure gives the worked knife edge, in section, a convex profile significantly different from the concave profile achieved by some other methods of sharpening. Archaeological Tartangan implements of the South-East of South Australia appear likely to have been resharpened by a similar method. I propose that it be known as the "rolling pressure technique".

The only early report I have discovered, of flaking by the application of pressure against the edge of an implement with a rotary motion, is the observation by Basedow (1907, p. 50). He reports that among the tribespeople south-west of Darwin the ventral edge of a strong bivalve shell (*Cyrena essingtonensis*) was used in the secondary pressure chipping of the edges of stone spear heads. The spear head was gripped in the left hand, and the shell, with the umbonal portion in the palm of the hand, convex surface outwards, was held firmly with all the fingers of the right hand, in such a way that the ventral edge of the shell was away from the palm of the hand. This border was pressed against the edge to be chipped and by careful wrenching of the right hand in such a direction that the thumb moved downwards, the required chipping was done.

By test this process, which is a kind of pressure flaking, yields a highly characteristic scar type and such work is apparent on *pirri*-like small blades of spears (in our Museum) from the Katherine River area.

A similar technique is used, with a piece of quartz as presser, in the making of temporary saw edges on long blades in several different parts of Australia. I have seen it at Yuendumu and among the Pitjandjara. Here the sharp edge is rolled against the margin to produce serrated flake scars.

['Tula] and ['kandi], the edges of which have been tapped with the flat face and the edge of a boomerang or any similar hardwood piece, used as a mallet, in the manner practised by Walpiri, Ngalia and Anmatjera men when resharpening stone implements, also have a characteristic scar form.

There are numerous variations in the methods of sharpening by tapping with wood. In November 1963 I saw a Ngadadjara man at Gill Pinnacle use the flat base of the head of his composite, single-wooden-hook-barbed-spear to tap off a flake or two from the stone blade fastened at the handle end of his spearthrower. The quick and casual way in which he did this indicated a technique of long standing.

As he sat he held the spearthrower in his left hand, the hooked head running obliquely behind him and the handle end, with its stone, lying cushioned by his hand, on his thigh. The spear lay in front of him, its point near and the shaft directed away from him, slightly to the right, with the butt end resting on the ground. He had been scraping the spear tip. Taking hold of the spear just behind the join of the flat head piece he brought it smartly down with a surprisingly well controlled series of movements and knocked off a row of tiny flakes from the ['kandi] in his spearthrower. In a matter of moments the operation was complete and he resumed the scraping of the spear point, the object of his attention when the stone had developed signs of bluntness.

DISCUSSION

Looking at the present-day Australian cultures we see that all the living peoples have similar basic needs for stone tools or substitutes.

Sedentary tribespeople may tend to have more possessions, nomadic ones have had to adjust needs to the necessities of travel and be more lightly burdened.

A people wearing skin cloaks have additional tool needs over those who habitually are naked. Those who live near water and eat fish need toggles, hooks or barbed spear heads, absent when their meat foods exclusively are the larger mammals such as kangaroos, while the very impoverished relict peoples of the western part of the Western Desert such as the Wanman, Mangala and Mandjildjara, whose daily animal diet is virtually confined to lizards and ['witjuti] grubs, use spears only in rare bouts of fighting and therefore tend to preserve archaic forms of weapons and may carry nothing during their hunting forays beyond a short throwing club. This latter is an all-purpose implement suitable for digging, hurling and, if armed with a resin-hafted ['kandi] flake, is useful for all ordinary cutting purposes.

The present-day *tula* of the Lake Eyre Basin and country to the north, shows vital technical differences in its processes of manufacture which differentiates it strongly from the ['kandi] made and used by Nakako, Pitjandjara and other peoples of the Western Desert.

The *tula* is a stone which has been systematically prepared on and knapped from a core by striking at a carefully chosen point on a prepared platform in such a manner that a potentially discoidal flake is detached. The pot-lid flake of Roth (1904), the flake has a sizeable platform piece on one side of the disk. The skill with which it is made, the consistency of form and the numbers of similar-sized flakes which may come together in a single traded parcel suggest a highly skilled, almost professional approach to implement making.

I have long known of this important difference between *tula* and *kandi* but the overall significance was at first masked by knowledge that the tribes on the Western Desert fringe commonly use some of the many detrital and insolation flakes which lie almost everywhere in their country, and it was assumed, with no real grounds, that when they had to use mined flakes they would make *tula* types. It is now clear that even when breaking out stone from their mines these people do not use the sophisticated techniques of the *tula* maker but employ only the crudest modes of obtaining their requirements. Their flakes originate from the breaking up of large boulders and their further reduction is by a crude hit-or-miss procedure and leads to random pieces of small size, from which final selections of flakes can be made.

This brings up a point important for the archaeologist. A Nakako or Pitjandjara ['kandi] flake is placed in a chisel or on the end of a spearthrower handle and resharpened many times, then it may be turned about so that two opposite margins become "worn". Finally it assumes a character which has led the archaeologist to suggest it is a tool type of its own. In Australia it has been termed the *burren* adze.

When a ['tula] is resharpened to the limit in the most usual manner it becomes the so-called "*worn tula*" or "*tula slug*" of the archaeologist. In such a specimen the upper margin of the platform becomes the median keel of the "slug". Allowing for casual variations in the methods of use and rehafting which can determine the final appearance, the differences between the *burren* slug and the "*worn tula*" bear witness to the existence of two entirely different procedures in manufacture which probably have had entirely different histories of origin. Some archaeologists confuse the two types.

There should be room, in the archaeologist's list of named types, for recognition of an implement like the ['kandi]. The objection which some may make is that a new ['kandi] flake, being merely a

simple one, is not recognizable. It only becomes important if found hafted with resin, or when retrieved after use at some stage of resharpening, when gradually it becomes another archaeological "implement type" the "*burren* slug".

The following type of incident has occurred to me several times when collecting archaeological ['kandi] implements in tribal territories where ['kandi] are still actively in use and the vagaries of archaeologists completely misunderstood by aboriginal inhabitants. I quote from a 1957 entry in my journal, made at Lightning Rocks, in Ngadadjara territory. We had arrived there one afternoon to find a small nomadic party in temporary residence while travelling west to Warupuju, a journey of about 70 miles. I went collecting archaeological stone implements on red sandhills near the native well on the north side of the granite outcrop and was soon busily picking up "worn" ['kandi] which lay about in profusion on the wind-eroded dune. Most of them were ones reduced to the *burren* condition.

"One of the old men came up and politely asked to see what I was picking up. He looked at me a little sorrowfully, and said in his Ngadadjara tongue, 'Those are useless!" He drifted away and half an hour later he returned with a small handful of primary flakes of the same stone and pressed them into my hands. To pick up worn ['kandi] stones my need must have been very great!". This points up a difference between the living way of seeing things and that of the archaeologist.

CONCLUSION

In 1964 it was still possible, in more than one area of Australia, to see aborigines knapping flints, cherts, quartzites and other rocks, employing a variety of techniques, and using and resharpening several kinds of these tools. The tools in many instances are similar to those which have been the stock-in-trade of various peoples of the Stone Age past, and certainly ones used for many centuries in Australia.

Yet so little advanced is our appreciation of this fact, that the owners of this kind of data have not been the subject of a single specially ordered study. Therefore an observer like the present author, has been able to see and learn about more than one technique which must be age-old in its application yet has altogether escaped modern notice. Some of his observations were first made as long ago

as 1921 and at intervals since then when casual opportunities have occurred for field work. Only very few observers have ever put pen to paper specifically on the subject of stone working among living Australians.

For this seeming apathy I blame in part the archaeologists, but doubtless such a statement will bring down a flood of wrath on my head. How many of todays' great archaeologists have spent time working with native peoples on the subject of stone knapping?

It seems evident to me that no student of stone implements and no archaeologist can afford not to test each of the methods of stone knapping outlined in this paper, to observe the types of flake scar which results from each, and apply the knowledge he gains to the clearer reading of the data provided by the implements he gathers during his excavations. Indeed it is high time that at least a few archaeologists should take note of Australian and New Guinea stone knappers and temporarily at least emerge from their cave holes to study at first hand the data provided by living peoples.

For several years yet it may be possible to see how Australians do this work, but time is passing. The Ildawongga of Jupiter Well are the last major remaining tribal group in Australia to be introduced to us. Up till now they have happily avoided contact with Western men but this year (1964) have been brought in to Papunya on the premise that they were "starving". These people surely could give stone-implement working data, entirely without outside influence, bias, or degeneration being imputed to them.

The Nakako, who have provided some data for this paper, met white men in 1961 for the first time. Four years earlier the present author had followed their tracks and seen vacated camps in the Blyth Range of Western Australia in company with Mr. W. B. MacDougall but could then find no trace less than about two weeks old. In 1963 they were still using their stone implements equally with a few precious pieces of metal which had newly come into their possession.

Bartlett (1964)[1] has shown that at least one of the peoples of the New Guinea Highlands still can make and use stone implement flakes for several purposes, so that even in New Guinea flint knapping could be studied.

(1) We have just heard of the death of Rev. H. K. Bartlett, in May, 1965. His collections and notebooks are in the South Australian Museum.

Should archaeologists avoid interpretations of archaeological material guided by knowledge gained from the living? Do they fear that "complexities" may thereby be eliminated from the art of archaeological deduction? Surely if we work from known bases better results must follow than if we adopt what seems to be a very prevalent myopic attitude. "Emus with their heads in the spinifex."

It should be noted that some of the facts given in this paper are supported by motion picture films. So far the originals of most of these have been viewed only with a hand viewer pending opportunities to finance the cost of reproduction and titling. When this is done some refinements in the descriptions given herein can be expected. Including films of observations on Bentinck Island (1960, 1963), in North Western Australia (1953) and field work in the Western Desert (1957, 1963) there are in the South Australian Museum about 3,000 feet of 16 mm film, principally in colour, recorded at 24 frames per second, which can yield information on stone working techniques.

ACKNOWLEDGMENTS

The combined expedition from the National University and the South Australian Museum received support for its work from several sources, including the United States Surgeon General, the Wenner Gren Foundation for Anthropological Research, the Australian National University, Canberra, and the Board of the South Australian Museum.

The authorities of Weapons Research Establishment helped with the use of two land rover vehicles for the 2,000-mile journey which the visit entailed.

Mr. W. B. MacDougall, Chief Native Patrol Officer at Woomera, helped in finding our principal nomadic hosts, the Nakako and Ngadadjara aborigines of whom some had encountered white folk for the first time only within the past three years. We also owe much to our helpers, Malutjukurupa (Harry), and Tommy Dodd.

I am indebted to my companions on the Expedition for their help and interest in these studies, which formed only a modest part of the aims of the Expedition.

Miss Brenda Hubbard drew most of the implements illustrated in this paper and I am indebted to Miss Faye Highett for her clever deciphering of my manuscript.

REFERENCES CITED

Angas, G. E., 1847: Savage life and scenes in Australia and New Zealand, London, 2 vol.

Bartlett, H. K., 1964: Note on flint implements found near Nipa, Central Papuan Highlands. Rec. S. Aust. Mus., Adelaide, 14, 669-673.

Basedow, H., 1907: Anthropological notes on the Western coastal tribes of the Northern Territory of South Australia. Trans. Roy. Soc. S. Aust., Adelaide, 31, 1-62.

Macfarlane, W. V., 1964: Water and salt metabolism of primitive people. Man in the Pacific, Honolulu, 3 April 1964, 5-6.

Roth, W. E., 1904: North Queensland Ethnography: Bulletin No. 7, Brisbane.

Tindale, N. B., 1941: Hand axe used in the Western Desert of South Australia. Mankind, Sydney, 3(2), 37-41.

——— 1957: Culture succession in South Eastern Australia from Late Pleistocene to the present. Rec. S. Aust. Mus., Adelaide, 13(1), 1-49.

——— 1957: Dated Tartangan implement site from Cape Martin, South-East of South Australia. Trans. Roy. Soc. S. Aust., Adelaide, 80, 109-123.

Tindale, N. B. and Noone, H. V. V., 1941: Analysis of an Australian aboriginal's hoard of knapped flint. Trans. Roy. Soc. S. Aust., Adelaide, 65, 116-122.

A NEW SPECIES OF HOLOCHILA (RHOPALOCERA, FAMILY LYCAENIDAE) FROM VICTORIA AND SOUTHERN NEW SOUTH WALES

By NORMAN B. TINDALE, South Australian Museum

Plate 14 and text fig. 1-4

SUMMARY

A new species of Lycaenid, *Holochila goodingi* Tindale is described from subalpine valleys of South Eastern Australia. Some notes and distribution records are given for kindred species.

INTRODUCTION

An elusive form of *Holochila* has been taken on a few occasions, and seen flying on others, in southern Victoria during the past 40 or more years.

In 1962 Mr. C. G. L. Gooding showed me two specimens which he had received from Mr. V. Smith, who had taken a small series at the junction of the McAlister and Barclay Rivers, Victoria, on the 11th and 12th of November 1950. Previously on 20 November 1919 Gooding had taken a female example at Moe, and in November 1962 had seen but missed taking another specimen perched on a native clematis vine in a grove of eucalyptus near a fern gully at Buln Buln, Victoria.

Mr. J. C. Le Souef earlier also had shown me two specimens he had taken at Warragul in March 1939; they were in fact the first two butterflies he had ever collected. On 12 January 1963 I took a worn example, which seemed to be the same species, near a creek above Tom Groggin, New South Wales, at an elevation of about 3,500 feet in a *Pomaderris apetala* thicket among Mountain Ash trees. Still more recently Mr. D. F. Crosby has sent me a male specimen from Cement Creek, Victoria, taken in December.

Study of these specimens has indicated the presence of a rarely taken new species, and this paper is the result.

I am indebted to Messrs. C. G. L. Gooding, J. C. Le Souef and D. F. Crosby for the loan of material. Mr. Gooding kindly has deposited the type specimens of the new species in the South Australian Museum and Mr. Le Souef has given one paratype.

Opportunities were taken to check the G. A. Waterhouse Collection at the Australian Museum, Sydney, and the material in the C.S.I.R.O. collection at Canberra. I am indebted therefore to Mr. C. N. Smithers of the Australian Museum and to Dr. D. Waterhouse and Mr. I. F. B. Common of the Entomological Branch, Canberra, for courtesies received.

Holochila genus Felder 1862

Holochila Felder 1862: 490. Type species, *Holochila absimilis* Felder 1862.

G. E. Tite (1963) recently revised the species of the genera allied to *Candalides* and has revived Felder's generic name for about 20 species formerly placed chiefly in *Candalides*. That genus is now restricted to its genotype, *Candalides xanthospilos* (Hübner).

Tite placed six Australian species in *Holochila* but regarded one, *H. persimilis* (Waterhouse) as of uncertain status. One species is found only in the Schouten Islands, and others range from Misol to the Aru Islands and through New Guinea to the Louisiade Archipelago.

In the present paper I recognize *H. persimilis* as a valid species and add a seventh species to the Australian list.

Tite, in his review, indicated the relatively scant material he had available for study of some of the Australian species. I take this opportunity to list some of the more significant localities and specimens represented in the collections to which I have had access.

Holochila goodingi sp. nov.

Plate 14, fig. 1-6a and text fig. 1

Male. Forewing purplish-blue with wide black margin along costa; a narrower one on termen; the dark markings of termen extend inward midway between the veins to form a series of obscure dark triangles; a broad discal patch of sex scales extends towards termen along M_3, Cu_{1a} and Cu_{1b}; it tends to form a broad trident-shaped area, with special scales lying between the veins as well as along them.

Hindwing purplish-blue with dull black costal band and terminal marks as on forewing. Wing below pale silky-blue, almost grayish-white, with inconspicuous black spots and marks; these spots are more conspicuous in basal half of hindwing.

Forewing length 15 mm, expanse 33 mm.

Female. Forewing broadly dull black with a circular discal white patch; this extends towards base with a bright blue flash; hindwing dull black with a discal area flashed only with blue. Wing beneath similar to male, but with evident traces of the discal white spot of forewing above.

Forewing length 17 mm, expanse 36 mm.

Loc. Victoria: McAlister River, V. Smith, 12 November 1950, holotype male and allotype female, same locality, 18 November 1950, in South Australian Museum Collection, presented by C. G. L. Gooding (no. I.19133); Moe, 20 November 1919, C. G. L. Gooding, paratype female in his collection; Warragul, in Bull Swamp four miles south of the town, 20 March 1939, J. C. Le Souef, two paratype males, one specimen in his collection, the other (I.19123) in S.A. Museum; Delburn, 18 December 1962, A. M. Lucas, paratype female in his collection; Cement Creek, 14 December 1953, D. F. Crosby, paratype male in his collection. New South Wales: Tom Groggin, at 3,500 feet, 12 January 1963, N. B. Tindale, presented to S.A. Museum.

The male genitalia have claspers of the same type as *H. consimilis,* terminating in two outwardly directed spines (fig. 1). In *H. consimilis* there is an additional spine in all the specimens I have examined, including the material originally figured by Waterhouse (1942, p. 123).

H. goodingi is clearly a distinct species related to *H. consimilis,* differing in the darker purplish-blue colour and the wide black margins of the male and in the female by the smaller white discal spot of forewing. In the male of *H. consimilis* there are also present terminal black triangular markings but these are far less conspicuous a feature of the wing markings.

I have considered the possibility that *H. goodingi* is a southern subspecies of *H. consimilis* but judge them to be separate species.

In the trident form of the male sex brand on forewing it is closest to *H. consimilis,* but the special scales on the wing itself are more extensive.

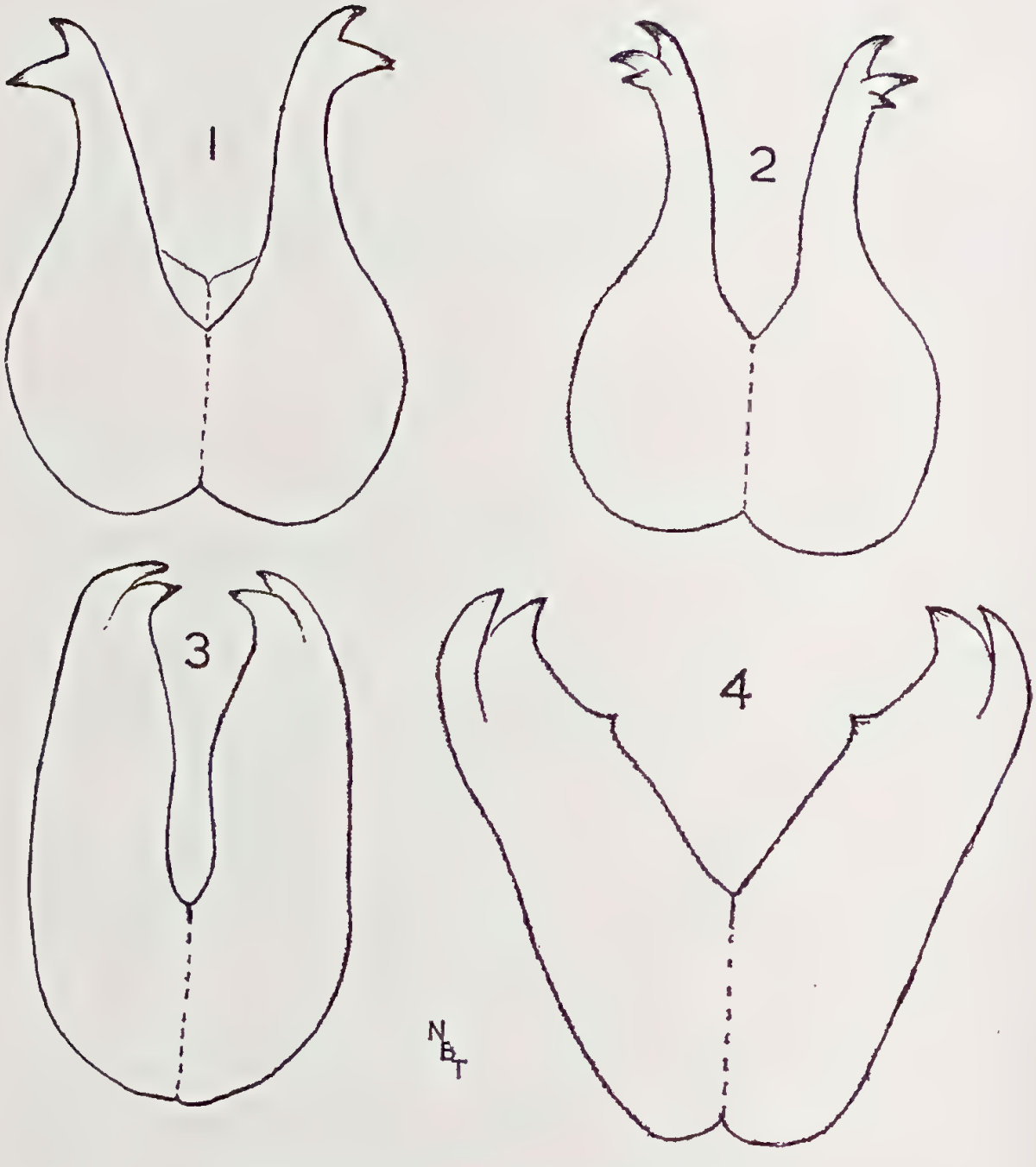


Fig. 1-4. Male claspers of species of *Holochila*.

Fig. 1. *Holochila goodingi* Tindale, Warragul, Victoria (specimen I.19123).

Fig. 2. *Holochila consimilis* (Waterhouse), Mt. Tambourine, Queensland (specimen I.19132).

Fig. 3. *Holochila absimilis* Felder, Atherton, Queensland, 22 March 1906 (specimen I.19127).

Fig. 4. *Holochila persimilis* (Waterhouse), Mackay, Queensland (specimen in Waterhouse Collection, Australian Museum).

There is a single female from Eden taken 12 November 1914 (Marked Z4 and KL 16521) in the Waterhouse Collection, and there placed with *H. consimilis,* but evidently it is this species. The white patch on the forewing is similar in extent to that on the figured female specimen from Delburn. Like other female examples of *H. goodingi* it lacks traces of any white patch on the hindwing.

Mr. C. G. L. Gooding has seen the species flying around a native clematis near Buln Buln and believes this is the food plant. Flowering specimens of this vine were kindly identified for me by Dr. H. Eichler, as *Clematis glycinoides* D.C.

Holochila consimilis (Waterhouse) 1942

Fig. 2

The type is from Killara, near Sydney, and the species has been recorded from Stanwell Park and Narabeen in the Sydney area, also from Ballina, Lawson, the Blue Mountains and from Lismore and it ranges northward to Southern Queensland.

The female has the white discal patch on forewing suffused with blue along the inner marginal side and towards the base; the hindwing has a blue suffusion over the whole area of the discal patch; occasionally a few white scales appear near the centre of the patch.

The male genitalia, described and figured by Waterhouse (1942, pp. 123-124) were found in the Australian Museum Collection and re-examined. The preparation is from a male labelled Sydney, 27 November 1941, K., G. A. Waterhouse. It may be presumed the K. stands for Killara. One of the claspers is intact, the other seems to have suffered *postmortem* damage. As normally viewed the full length of the larger lateral spine is not appreciated; when viewed obliquely it is seen to be longer than the width of the clasper itself; the third spine is very evident from the same direction.

The original paper did not mention details about the type material. There is a specimen KL. 16533 in the Australian Museum marked as Holotype, labelled Sydney, N.S.W., 3 December 1941 K., G. A. Waterhouse; here again the K. presumably stands for Killara. An allotype female is marked (no. KL.16531) and labelled as from Killara, 29 December 1935. The other New South Wales specimens are from Lawson, Blue Mountains, Clifton, Helensburgh and Stanwell Park.

In the C.S.I.R.O. collection there are others from Narara (males in September, females in November), Ebor (January), Saddleback (February). The last named were taken by H. Thirkell.

Mr. C. G. L. Gooding has specimens from Manly Vale (December) and Grafton (June and August).

Queensland localities are Toowoomba (October and November) and Mount Tambourine. I have examined some 40 males and 28 females.

Holochila absimilis Felder 1862

Fig. 3

The type is from Ash Island, New South Wales, and the reported range of the species is from the Dandenong Range in Southern Victoria to the Cairns district, Queensland.

In the female the white patch on the hindwing is present but does not run to the costa. The blue flash on the white patch of forewing usually covers the inner half of the discal area and is present to a lesser extent in the same position on the hindwing.

The male genitalia have been figured (fig. 3) for comparison with *H. persimilis* from which it differs in the absence of the spine on the shaft of the clasper.

Of this species 57 male and 53 female specimens have been examined from the following localities:— Victoria: Dandenong Range. New South Wales: Kiama (November), Bundeena (September), Jamberoo (February), West Ryde (September); Sydney: Yamba (September), Narara (December), Grafton (October), Brunswick Heads (May, reared material), Port Macquarie (February), Lismore (October), Ballina, Burleigh Heads. Queensland: Brisbane, Bunya Mountains.

I have not seen specimens from northern Queensland. According to Tite (1963, p. 211) specimens from North Queensland show racial differences, examples from Mackay being intermediate, with males like the northern form and females like those from Brisbane. Unfortunately he has not differentiated between *H. persimilis* and *H. absimilis*—his records should be considered with this in mind.

The Dandenong Range pair in the Australian Museum, taken many years ago by C. French, do not differ from typical specimens from Ballina, New South Wales.

In this species the male sex scales are confined to the veins of the forewing and do not extend on to the wing surface between. Bred and captured specimens from Ballina clearly indicate that there is no difference in bred specimens in the development of this character.

The late Dr. G. A. Waterhouse reared a male specimen which pupated 31 December 1940 and emerged on 27 September the following year.

Mr. Tom Guthrie, in May 1963, reared several specimens from pupae on *Cupania,* associated with black ants. The species has also been reported as feeding on a native *Wisteria.*

Holochila persimilis (Waterhouse) 1942

Fig. 4

The type series of thirteen males and seven females from Mackay, is in the Waterhouse Collection at the Australian Museum. A male dated February 1899 has been marked by Waterhouse as Holotype with register numbers L.3255 and KL.16496. The specimens were taken by R. E. Turner.

The male clasper of a Mackay example, January 1899, R. E. Turner, is preserved on a celluloid strip pinned beneath the specimen. It seems to be the one figured by Waterhouse (1942, p. 123). It was not well shown in the original and therefore has been redrawn, as fig. 4. It will be noticed that a spine, not shown in the earlier drawing, is present about half way down the shaft of the clasper. This spine is absent from the examples of *H. absimilis* I have examined.

It seems clear that the species is a perfectly valid one. The Mackay males have a relatively conspicuous diffuse patch of sex scales on the forewing as well as on the veins and the wing colour is best described as lilac; in southern males the sex scales perhaps tend to be slightly less conspicuous. The females have white patches on both fore- and hindwings; these are broadly margined towards the base with blue scales, somewhat as in *H. absimilis.* Females of the latter species tend to be larger and to have the white patch of hindwing smaller and narrower than in *H. persimilis.*

In addition to the type series I have seen 29 males and 19 females from localities between Narara, New South Wales and the Cairns district in Queensland.

Localities and months of capture are:—New South Wales: Narara (November), Port Macquarie (February), Grafton (August, October), and Byron Bay (January). Queensland: Killarney (February), Southport (January, February). The male figured by Common (1964, p. 121) is from Brisbane (14 Feb. 1907, *ex* A. J. Turner Collection). Brisbane (January, February), Bunya Mountains, 3,000 feet (January, February), Fairy Bower near Rockhampton (January), Mackay, Cairns, Kuranda (January, February).

Holochila helenita Semper

The type is a male from Cape York in the British Museum. The Australian range of the species is from Sydney to Cape York, and a separate race, *H. h. dimorpha* (Röber) 1886 is recognized from New Guinea.

Messrs. I. F. B. Common and M. S. Upton took a series of five males and eight females at Lockerbie on Cape York, Bamaga and Iron Range, between 1st and 12th April 1964, also two females at Crystal Cascades on 24th March 1964. The trident sex mark on veins M_3, Cu_{1a} and Cu_{1b} is very evident.

In all the females taken on Cape York the white patch of hindwing is as large as that on the forewing and reaches to the costal margin, without traces of blue scales, except for a slight fringe on the inner side of the forewing spot.

Holochila margarita Semper 1879

The type, from Bowen, Queensland is in the British Museum and the reported range is from Sydney to North Queensland; a race *H. m. maria* (Bethune-Baker) 1908 extends the distribution to New Guinea, the Aru Islands and Misol.

There are six specimens including a female in the Gooding Collection from Grafton (June, September and December).

The Waterhouse Collection material (36 males, 33 females) is all from Queensland, including Burleigh Heads, Stradbroke Island, Mackay, Gayndah, Cairns, Kuranda, Herberton, Claudie River, Thursday Island and Prince of Wales Island.

Messrs. I. F. B. Common and M. S. Upton took examples of both sexes on Cape York, a male on 26 March 1964 at Bamaga, a single female at Lockerbie, 2 April 1964, and another at El Arish on 7 March 1964.

Other localities represented in the C.S.I.R.O. collections are five males from south of Atherton (May), Innisfail (November), Lake Barrine (May) and Montville (August).

The male of this species is well characterized by the trident sex mark on the forewing.

The male example figured by Common (1964, p. 123) was reared from a pupa taken at Yeppoon; it emerged on 14 January 1962; the female he shows is from Brisbane.

In the female of this species the bluish flash at the base of the large white patch of the forewing covers much of the basal half of the area and also extends along the inner margin; this contrasts with the more limited areas covered with blue in the case of the corresponding spot in *H. helenita*. The size of *H. margarita* females tends also to be greater than in that species. In all female specimens examined the white of the hindwing patch runs to the costa.

Holochila gilberti (Waterhouse) 1903

The type is from Port Darwin and it has been taken also at Adelaide River. Common (1964, p. 123) figures a female from Melville Island. The Queensland localities reported for this species are doubtful.

A specimen taken at Darwin by F. P. Dodd in April 1909 is in the C.S.I.R.O. collection.

REFERENCES CITED

Common, I. F. B., 1964: Australian Butterflies. Brisbane. 131 pages.

Felder, C., 1862: Verzeichniss der von dem Naturforschern der k. k. Fregatte Novara (Macrolep.) Verh. zool. -bot. Ges. Wien, 12: 473-496.

Semper, G., 1879: Beitrag zur Rhopalocerenfauna von Australien. J. Mus. Godeffroy, 5: 138-194 (reprints were issued in 1878 *fide* Waterhouse).

Tite, G. E., 1963: Revision of the genus *Candalides* and allied genera (Lepidoptera: Lycaenidae). Bull. Brit. Mus. (nat. Hist.), Entomology, London. 14(5): 197-259.

Waterhouse, G. A., 1903: Notes on Australian Rhopalocera: Lycaenidae, pt. 3. Proc. Linn. Soc. N.S.W., Sydney. 28: 132-275.

———— 1942: Notes on Australian butterflies in the Australian Museum. No. 2. Rec. Aust. Mus., Sydney. 21: 122-125.

EXPLANATION OF PLATE 14

Holochila goodingi Tindale

Fig. 1. Holotype male, McAlister River, Victoria, 12 November 1950, V. Smith, *ex* Gooding Collection, I.19133 in S. Aust. Museum; upper side.

Fig. 1a. *ditto* underside.

Fig. 2. Paratype male, Warragul, Victoria, March 1939, J. C. Le Souef, I.19123 in S. Aust. Museum; upper side.

Fig. 2a. *ditto* underside.

Fig. 3. Paratype male, same details as fig. 2, in J. C. Le Souef collection.

Fig. 3a. *ditto* underside.

Fig. 4. Allotype female, McAlister River, upper area, 18 November 1950, V. Smith, *ex* Gooding Collection, I.19133 in S. Aust. Museum; upper side.

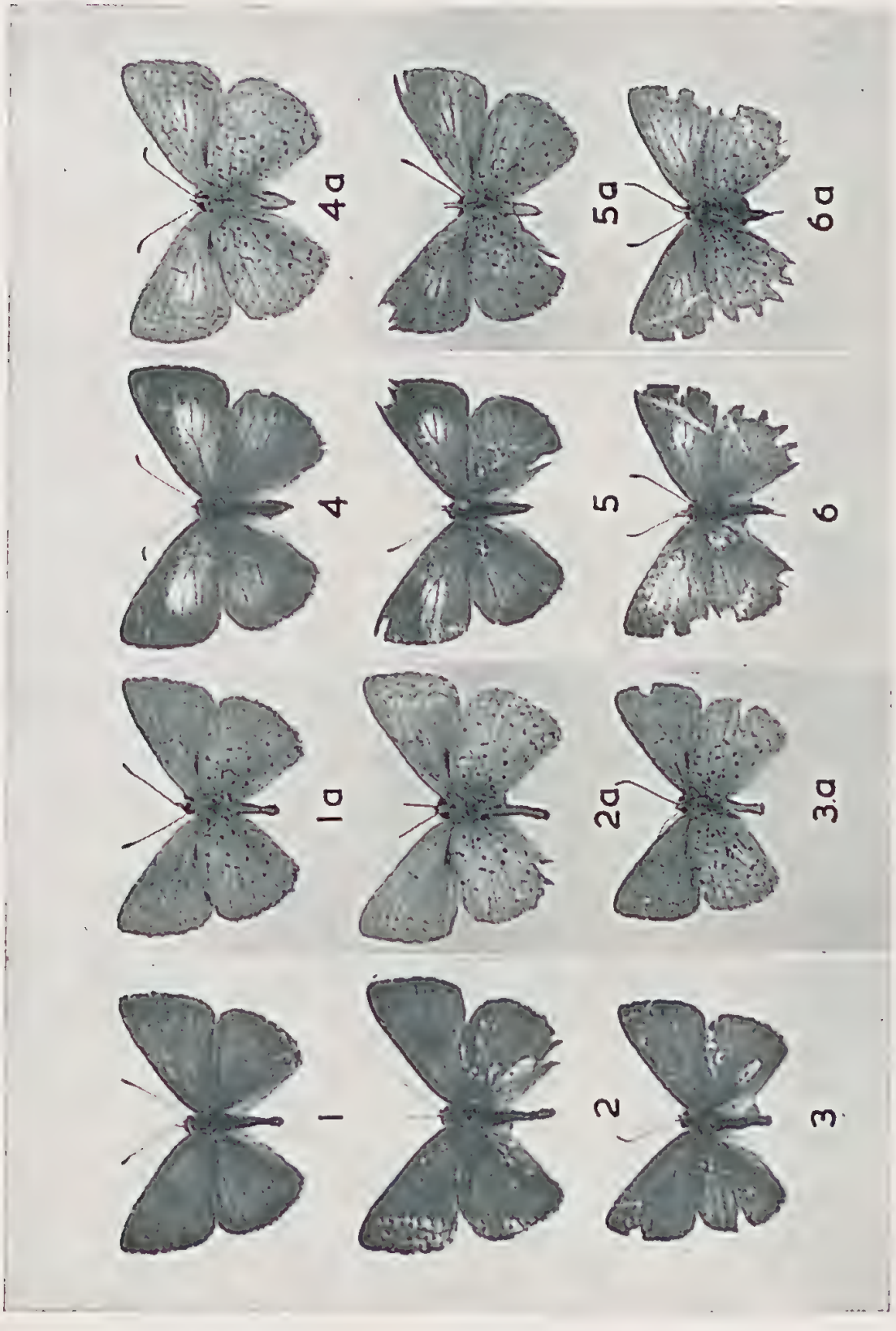
Fig. 4a. *ditto* underside.

Fig. 5. Paratype female, Delburn, Victoria, 18 December 1962, A. M. Lucas, in his collection; upper side.

Fig. 5a. *ditto* underside.

Fig. 6. Paratype female, Moe, Victoria, 20 November 1919, C. G. L. Gooding, in his collection, upper side.

Fig. 6a. *ditto* underside.


4a
5a
6a
4
5
6
1a
2a
3a
1
2
3

NOTES ON SOME WESTERN AUSTRALIAN LEPIDOPTERA-RHOPALOCERA WITH DESCRIPTION OF A NEW SUB-SPECIES OF ANISYNTA ALBOVENATA

By FRANK E. PARSONS

Plate 15

Rhopalocera have been collected in Western Australia during three car journeys extending from Geraldton in the north to Albany in the south, and to Norseman and Esperance in the eastern part of the State.

On the first visit, during October and November 1959, we found, between Norseman and Esperance, a series of a Hesperid, *Anisynta albovenata,* thus extending the range of the species from Gunnedah in New South Wales through South Australia to about 450 miles west of the Western Australian border. The Western Australian insect clearly is a new subspecies, and is described below.

The second visit was made between April 1961 and February 1962, and the third from October to the end of December of that year. I was accompanied on my first visit by Mr. F. M. Angel, who added series to his collection.

Ialmenus inous Hewitson 1865

This butterfly appears to be confined chiefly to the coastal belt from Fremantle to Bunbury, and on the first two visits fair numbers were collected in the sandhills at Bunbury. On the third visit I found them extremely numerous about five miles north of Mandurah and in one day collected some 70 pupae in less than one hour. Approximately one-half of them were parasitised.

The larvae and pupae, attended by many small black ants, were found either on dead leaves or in the sand under leaning branches. The food plant is a sprawling bush of a species of *Acacia.*

I could find none before the first week of November, and by mid-December they had become scarce again.

Hypochrysops halyaetus Hewitson 1874

A dozen of the adults were collected at Geraldton at the end of October 1959; they were not at all plentiful and considerable effort went into finding them.

On my second trip to Western Australia early in November I found a spot in the Chittering district a little more than 40 miles from Perth where they were present in considerable numbers. Four trips were made to the area during the following three weeks and over 160 specimens were collected, but I could find no indications as to the likely food plant. By the end of November their flights were over and on the last occasion none could be found.

On my third trip to Western Australia I visited the same spot in the Chittering district at the end of October 1963, but there was no sign of this butterfly. I visited the spot again on 7th November, when they were as plentiful as in the previous season and was able to catch a representative series. By the last week in November they had all disappeared. Evidently they have a very short flight season and should be sought during the first three weeks of November. They are very easy to net and appear only on the spike of small yellow flowers of *Verreauxia reinwardtii,* a plant not very widely distributed; it occurs chiefly on the gravelly ironstone soils of the Darling Range.

Ogyris idmo idmo Hewitson 1862

During the first three weeks of November a few of the Western race of this rare species were flying in the same place as *Hypochrysops halyaetus.* I saw them settled only on flowers of the white *Pimelia* and collected two males and six females.

Hesperilla donnysa albina Waterhouse 1932

Several pupae of this subspecies were collected from their shelters in sword grass at a swamp about three miles south of Fremantle, during early September, and several males were caught while settled on sword grass at Albany, during the first week in December.

Anisynta albovenata fuscata subsp. nov.

Plate 15, fig. 5-8

Male above, dark grey-brown. Fore-wing with a spot at end of cell, three subapical spots, two below these, nearer the termen in areas 4 and 5, spots in 2 and 3, and a very small and faint spot just above vein 1; the subapical spots and those in 4 and 5 are very small.

1
5
2
6
3
7
4
8

Underside of forewing dark grey-brown, the basal half a shade lighter than the outer half; the ends of the veins white, and the spots reproduced as on the upper side. All spots whitish, not yellow as in the subspecies *A. albovenata weemala.*

The male hindwing has no spots on upper or lower sides, but on the lower side all the veins are white from their bases to the termen.

Female above, dark grey-brown, with all the spots as in the male, but they appear more pronounced. Female underside, marked similarly to the male, but the spots again are more pronounced. Length of forewing, male 15.7 mm, female 18.0 mm.

This race is distinguished from the South Australian one by its more prominent markings, larger size, and the much darker colouring.

The average length of forewing in my specimens is:—male 15.6 mm, female 17.8 mm.

In a series of 25 examples of *A. a. albovenata* the average length of forewing is:—male 12.7 mm, female 15.1 mm.

The holotype male and allotype female bear the following data:—Male, Salmon Gums, W. Austr., 12 Oct. 1963. Female, Esperance, W. Austr., 14 Oct. 1959, and are deposited in the South Australian Museum Collection where they bear the number I.19134. In addition there is a paratype series of 20 specimens in my own collection including the specimens figured to show their under sides. A series (nine paratype males and three females) taken by Mr. Frank Angel during our first visit, are in his collection.

I am indebted to Mr. J. O. Wilson for the accompanying plate and to Mr. Norman B. Tindale for his interest and advice.

EXPLANATION OF PLATE 15

Fig. 1-4. *Anisynta a. albovenata* Waterhouse. 1. Male, Point Pearce, S. Aust. 11 Oct. 1942. 2. Male, underside, Ardrossan, S. Aust. 2 Oct. 1944. 3. Female, Point Pearce, 10 Oct. 1942. 4. Female, underside, Point Pearce, 11 Oct. 1942.

Fig. 5-8. *Anisynta a. fuscata* Parsons. 5. Holotype male, Salmon Gums, W. Aust. 12 Oct. 1963. 6. Paratype male, underside, same data as holotype. 7. Allotype female, Esperance, W. Aust. 14 Oct. 1959. 8. Paratype female, underside, same data as allotype.

THE AFFINITIES OF TYMPANOCRYPTIS MACULOSA MITCHELL (LACERTILIA-AGAMIDAE)

By F. J. MITCHELL

Figs. 1-2

SYNOPSIS

Cleared and stained skeletal material is used to compare the osteology of 14 species of the genera *Amphibolurus* and *Tympanocryptis,* and thereby reassess the generic status of the dragon described as *Tympanocryptis maculosa* Mitchell (1948).

It is concluded that the closure of the tympanic membrane is a secondary feature and that species referred to the genus *Tympanocryptis* should be primarily distinguished by the reduction of one phalanx of the fifth digit of the pes. Despite its possession of a concealed tympanic membrane and other features most strongly developed in *Tympanocryptis, maculosa* agrees with *Amphibolurus* in possessing primitive phalangeal formulae and is now considered a specialized member of that genus.

INTRODUCTION

In naming and defining the genus *Tympanocryptis,* Peters (1863) emphasized the closure of the tympanic opening and the absence of femoral pores as generic characters, and the combination of these two features proved a practical means of isolating a small number of species for taxonomic purposes. The description of *T. tetraporophora* Lucas and Frost, a species possessing one femoral pore on each side was accepted because of its obvious close relationship to the orthotype, *T. lineata* Peters. However, the description of a species with a concealed tympanic membrane, but possessing 5-8 femoral pores on each side and an *Amphibolurus*-like general habit as *Tympanocryptis maculosa* Mitchell, the close superficial resemblance between several spinous scaled species of *Amphibolurus* and recently described species of *Tympanocryptis,* and the discovery of an agamid (identity as yet

uncertain) possessing partial concealment of the tympanic membrane have cast doubt on the value of the enclosed ear-opening as the indicator of a monophyletic assemblage.

The present study was undertaken in an effort to find alternate means of defining these genera and, in particular, of reconsidering the generic status of *maculosa* on the basis of comparative skeletal morphology.

METHODS AND MATERIAL EXAMINED

Skeletons were prepared by standard clearing and alizarin staining techniques permitting calcified parts of the anatomy to be clearly distinguished. Cartilaginous parts were not differentially stained.

Five skeletons of *T. maculosa* were prepared from specimens varying in snout-vent length from 28 mm to 65 mm and compared with the following specimens in the South Australian Museum reference collection.

Species with an exposed tympanum:

Amphibolurus adelaidensis (Gray)—Two adult specimens collected at Eyres Sand Patch, Western Australia.

Amphibolurus reticulatus inermis (De Vis)—One subadult specimen collected at Muloorina, South Australia.

Amphibolurus maculatus gularis Sternfeld—Two adult specimens collected at Wolf Creek, Western Australia.

Amphibolurus pictus Peters—Three specimens; one subadult collected at Mount Eyre; one adult from Tailem Bend and one adult from Western Gawler Ranges, South Australia.

Amphibolurus diemensis (Gray)—Two adult specimens collected at an unknown locality in Tasmania.

Amphibolurus darlingtoni Loveridge—One adult specimen collected at Ooldea, South Australia.

Amphibolurus cristatus (Gray)—One subadult specimen collected at Koonibba, South Australia.

Amphibolurus decresii (Dum. and Bibr.)—Two specimens; one subadult and one adult collected at Mount Aroona, Flinders Ranges, South Australia.

Amphibolurus fionii Proctor—One adult specimen collected at Mount Wedge, Eyre Peninsula, South Australia.

Species with a concealed tympanum:

Tympanocryptis tetraporophora Lucas and Frost—Two adult specimens collected near Leigh Creek, Flinders Ranges, South Australia.

Tympanocryptis intima Mitchell—Three adult specimens; two collected at Finniss Springs and one at Etadunna, South Australia.

Tympanocryptis lineata lineata Peters—Two adult specimens; one collected near Port Lincoln, and the other near Adelaide, South Australia.

Tympanocryptis cephalus gigas Mitchell—One adult specimen collected in the Murchison District, Western Australia.

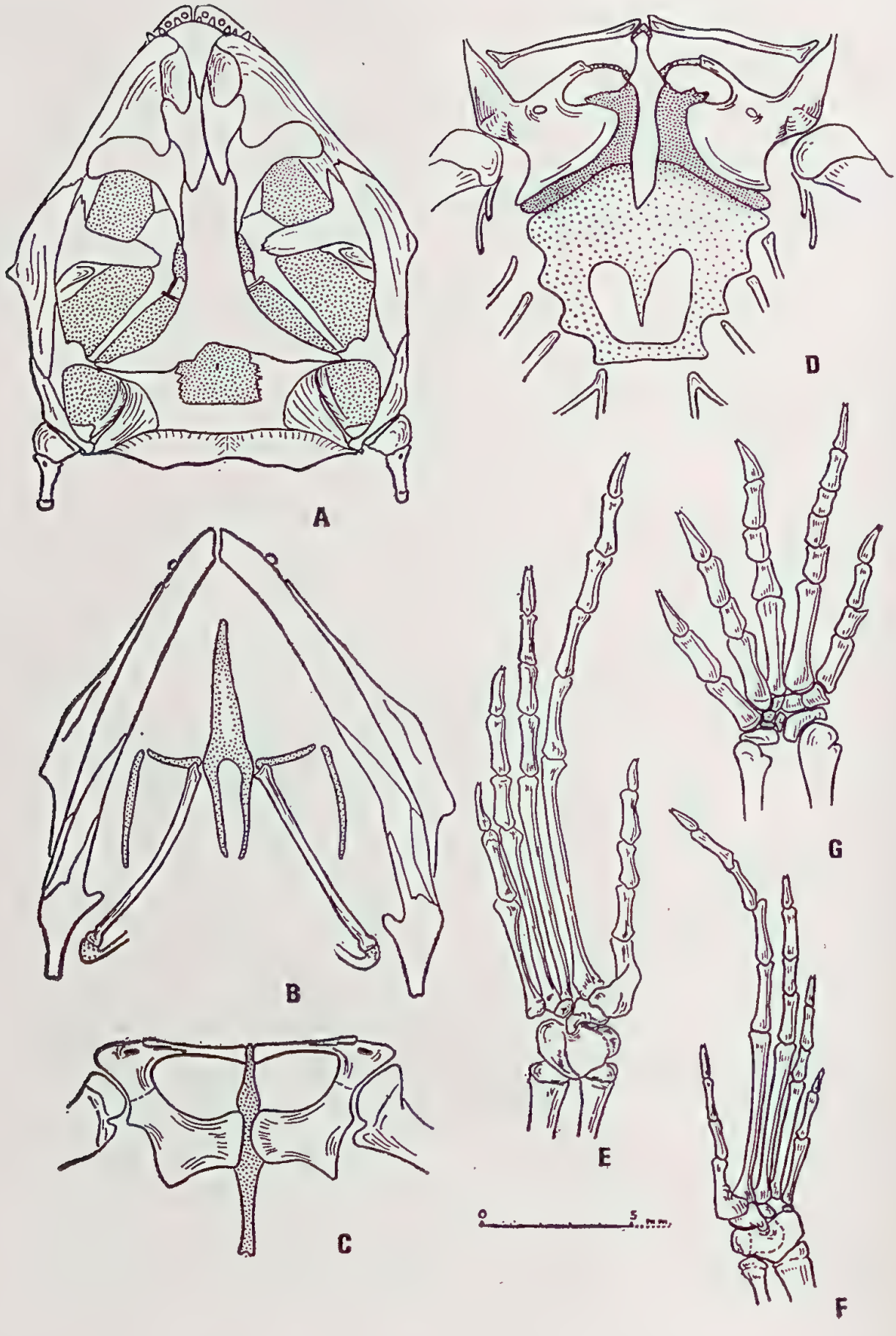
SKELETAL MORPHOLOGY

The following is a summary of the variation observed in a number of key features which were considered adequate to provide a guide to affinities.

The general skeletal morphology is relatively uniform and the range of variation appears to be in part correlated with body form and related behaviour. While possessing the basic pattern of *Amphibolurus*, the skeleton of *T. maculosa* shows several of the specializations most strongly developed in *Tympanocryptis*. Its skeletal detail is figured in fig. 1 and used as the main point of reference.

The Skull: The cartilage bones roofing the skull are subject to little variation other than relative proportions. The extent of penetration of the paired nasals between the prefrontals and the penetration of the premaxilla between the nasals are subject to interspecific variation. The relative proportions of the premaxilla appears to be constant and diagnostic, varying at the extremes from long, slender and acute in *A. maculatus gularis* through long, parallel sided and rounded in *A. diemensis* to short, wide and obtuse in *A. reticulatus inermis*.

Beddard (1905) accepted the osteology of *A. barbatus* as typical of the genus and used it as part of the foundation for his comparison with *Chlamydosaurus*. Apart from the fact that lizard osteology is subject to greater interspecific variation than was suspected by Beddard, the examination of several dried skulls supports Beddard's


A
B
C
D
E
F
G
0
5 mm

comparisons, but reveals *barbatus* to be atypical of the genus as a whole in several respects. The palatines meet on the midline in adult *barbatus* and Beddard contrasted this with the condition in *Chlamydosaurus*. In all species examined in the present study the palatines were clearly separated on the midline. Also, the premaxillary bone usually fails to reach beyond the posterior margin of the external nares and frequently it only extends approximately two-thirds the way along the median border. Species with short, wide premaxillas, such as *A. reticulatus inermis*, possess small external nares to match.

The parietals are invariably fused posteriorly but display wide variation in the size and form of the parietal foramen, which is greatly enlarged and emarginate anteriorly in most species. In many species there is also retardation or failure of ossification in median parts of the posterior border of the frontal (see fig. 1). In fully adult specimens of several species examined, *T. lineata, A. pictus, A. decresii* and in one each of the two specimens of *A. diemensis* and *A. adelaidensis* the parietal foramen is a simple perforation at or immediately behind the centre of the fronto-parietal suture.

In the large and probably senile specimen of *A. pictus* from Tailem Bend, South Australia, the perforation is in a backward extension of the frontal which intrudes the transverse line of the normal fronto-parietal suture to fill the parietal foramen. In all other species examined this foramen is enlarged to varying extents, and a large part of the cranial cavity remains unprotected through to adulthood. The relative size and shape of the parietal opening appears constant for adult specimens and could be of diagnostic value if required. The ontogenetic sequence of *T. maculosa* clearly shows the latter stages in the ossification of the parietal and indicates that the enlarged foramen undergoes little change in relative size or shape during development in this species. This feature is most strongly developed in species inhabiting open stony or sandy desert.

Fig. 1. *Tympanocryptis maculosa* (adult male)

A. Dorsal view of the skull oriented so that the frontal is at 90° to the angle of view.
B. Ventral view showing the relationship between the lower jaws and the hyo-branchial apparatus.
C. Pelvic girdle.
D. Pectoral girdle.
E. Pes of *Tympanocryptis maculosa.*
F. Pes of *Tympanocryptis lineata* shown for comparison.
G. Manus of *Tympanocryptis maculosa.*

The bones comprising the superior temporal arch vary considerably from one species to another. The jugal and post-orbital bones are in part compensatory in size and shape. *T. lineata, T. tetraporophora, T. intima, T. cephalus gigas* and *A. diemensis* possess enlarged jugals extending well upward into the temporal arch; *A. adelaidensis* possesses an enlarged jugal which is wide but not high. In *T. cephalus gigas* and *A. adelaidensis* the post-orbital bridge is conspicuously wide. In *A. maculatus gularis, A. cristatus, A. darlingtoni, A. reticulatus* and *T. maculosa* the jugal is comparatively slender and does not extend as far up the arch, the post-orbital frequently extending downward along the margin of the orbital vacuity. The post-frontals are absent.

The form of the remnant of the supratemporal in relation to the superior articulation of the quadrate is of interest. The supratemporal is rather superficially attached to the parietal process in *maculosa,* but in the majority of species it is a flattened splinter embedded in the lower lateral edge of the process. Its distal end passes under the squamosal where it thickens to articulate against the quadrate. In *A. fionii* and *A. decresii* the quadrate articulates well forward on the squamosal and the enlargement of the supratemporal under the squamosal is quite considerable.

The dentition is heterodont, the posterior 12 or 13 teeth in both upper and lower jaws being acrodont and strongly compressed and the anterior teeth subthecodont and conical. In *A. cristatus, A. diemensis* and to a lesser extent in *A. maculatus gularis* the posterior acrodont teeth are enlarged and tend tricuspid. Each central cusp is sharply pointed and the lateral cusps are flat or only slightly raised. The upper jaw closely overlies the lower jaw, the central cusps of the six enlarged posterior upper teeth interlocking into grooves in the outer face of the dentary. In *T. cephalus gigas* and *T. intima* the enlarged teeth in the upper jaw are inclined slightly so that the teeth themselves interlock. In both of these species the size of these teeth decreases rapidly towards the front and anteriorly are kept permanently separated by the interlocking of the enlarged incisors.

The first and second maxillary, first and second mandibular and the two or three premaxillary teeth are conical in all species except *A. cristatus* which appears to lack conical mandibular teeth. These teeth are firmly attached to the bone at the base, but are separated by porous bony septa. In all species referred to *Tympanocryptis,* including *maculosa,* they are considerably enlarged and slightly

recurved. An enlarged mandibular tooth fits into a notch in the upper jaw between the maxilla and the premaxilla on each side, and an enlarged maxillary tooth functions as a canine and overlies the dentary on each side. The lower jaw is slightly longer than the upper jaw to allow these teeth to interlock in this manner (see fig. 1).

Hyo-branchial Structure: The hyoid displays little variation from that figured for *maculosa* (fig. 1). The first branchial arch is strongly developed in all species examined, the bony ceratobranchial articulating on the body of the hyoid.

Because non-calcified cartilaginous structures were not adequately differentiated in the material studied it was not possible to trace the epibranchial I elements, but in several species, *T. maculosa* (see fig. 1), *T. lineata,* and *T. tetraporaphora* the ceratobranchial-epibranchial connection is very strong and the epibranchial can be seen turning abruptly away in a manner which suggests that it joins the cranial wall near the auditory structures. The ceratobranchial is also strongly developed in several species of *Amphibolurus* examined, but the epibranchial connection is usually weaker and situated further behind the quadrate.

Assuming the closure of the ear membrane reflects the need for substantial modification of the auditory mechanism, a detailed study of cartilaginous parts of the branchial arch and of the structure of the auditory capsule may reveal some significant parallels.

Pectoral Girdle: The detail of this girdle is composed of both stable and unstable characters. All species possess simple rod-like clavicles with no median fenestrae, have the scapula and coracoid fused in the adult, have a supra-coracoidal foramen, a lateral coracoidal fenestra formed by the extension of the calcified cartilage of the epicoracoid to join the anterior corner of the coracoid and a very distinct and heavily reinforced articulating glenoid for the forelimb.

The number of sternal ribs is three on each side in the majority of species with one rib attached to each xiphisternal horn, but some variation was noted. *A. maculatus gularis* possesses four sternal and no xiphisternal ribs; *T. tetraporophora* and *A. darlingtoni* also possess four sternal ribs, but the lower pair in each case are attached at the base of the xiphisternum. This also applies to one of the two specimens of *A. diemensis.* Single specimens of *A. pictus, A. adelaidensis* and *T. intima* possess three sternal but no xiphisternal ribs. The ribs are attached to the 9th, 10th, 11th and 12th vertebrae.

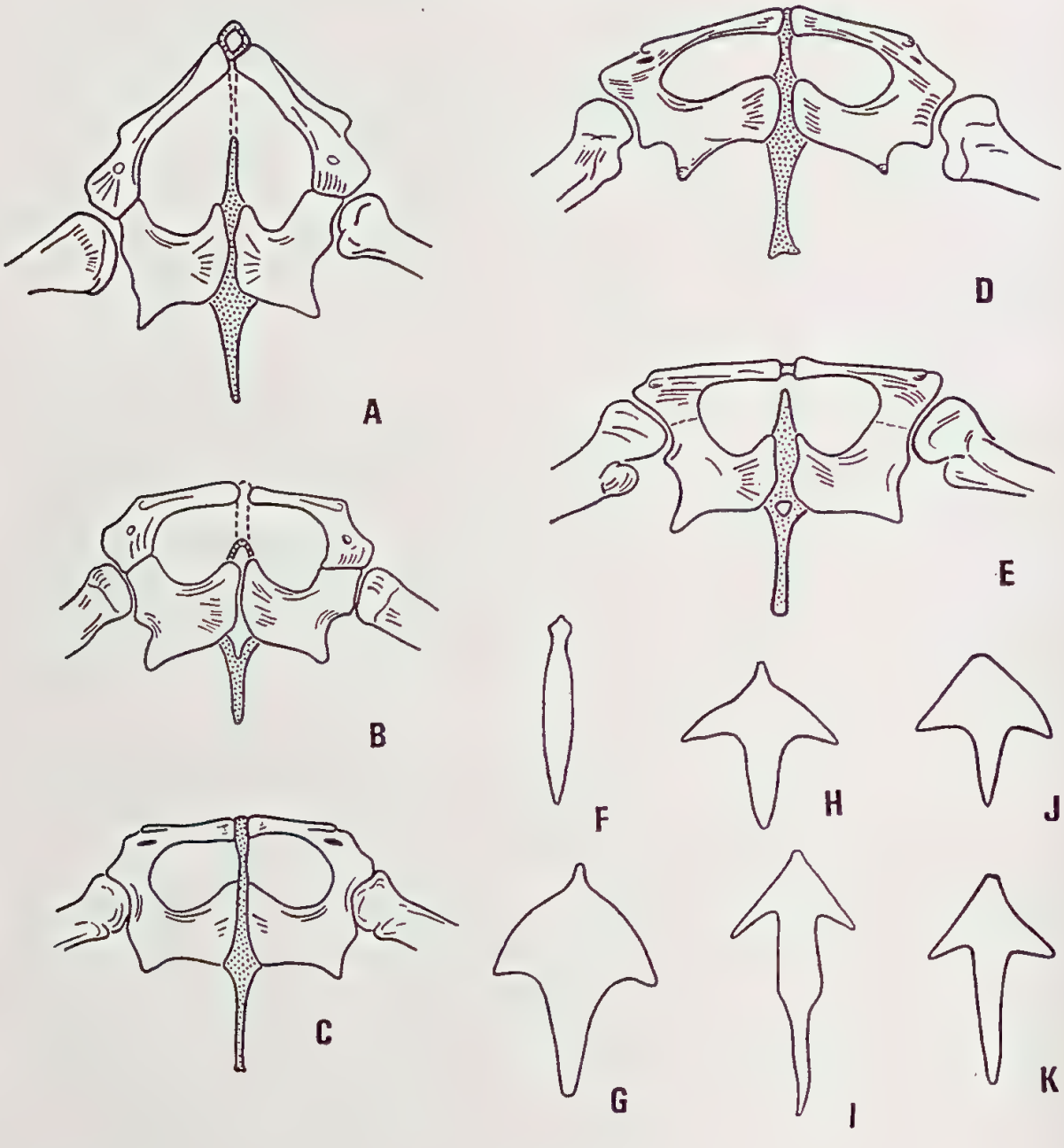


Fig. 2.

Pelvic Girdles of:—

A. *Amphibolurus maculatus gularis.*
B. *Amphibolurus pictus.*
C. *Amphibolurus adelaidensis.*
D. *Tympanocryptis lineata.*
E. *Tympanocryptis intima.*

Interclavicles of:—

F, G. *Amphibolurus pictus.*
H. *Amphibolurus adelaidensis.*
I. *Amphibolurus maculatus gularis.*
J. *Tympanocryptis tetraporophora.*
K. *Tympanocryptis lineata.*

The interclavicle is subject to wide variation, but the limited material available for study did not permit its interspecific stability to be adequately assessed. It varies from broad, short, arrow-shaped in *T. lineata* (fig. 2J), *T. tetraporophora* and *T. cephalus gigas* to broad, short, tending cruciform in *A. adelaidensis* (fig. 2H), *A. fionii* and *A. decresii* to long, arrow-shaped in *T. intima* (fig. 2K), *A. maculatus gularis* (fig. 2I), *A. reticulatus, A. darlingtoni* and *A. diemensis* to dagger-shaped in *T. maculosa* (fig. 1D) to simple blade-shaped in one specimen of *A. pictus* (fig. 2F) collected at Mount Eyre, South Australia. The interclavicle of *A. pictus* appears to be subject to wide individual variation. The interclavicle of the Western Gawler Range specimen is figured (fig. 2G) and that of the Tailem Bend specimen is long and broadly arrow-shaped (similar to fig. 2K). The interclavicle of *T. maculosa* is constant for the five specimens examined. *A. cristatus* has an unusual interclavicle. It is dagger-shaped with two oblique club-shaped lateral projections commencing two-thirds the way down the "handle".

Pelvic Girdle: Within the limitations of the material available for study the pelvic girdles appear constant and vary sufficiently to be of value as supporting data in species taxonomy.

The pubis and ischium are indistinguishably fused in adults of *A. adelaidensis, T. lineata* and *T. cephalus gigas* and retain a faint suture in young adults but are probably indistinguishably fused in senile specimens of *T. intima* and *T. maculosa.* Adults of *T. tetraporophora, A. decresii* and *A. fionii* possess firmly united bones but retain distinct sutures, while *A. maculatus gularis* (fig. 2A), *A. pictus* (fig. 2B), *A. darlingtoni* and in subadults of *A. cristatus* and *A. reticulatus inermis* these bones are clearly separate. The girdles of *A. cristatus* and *A. darlingtoni* are "open" structures similar to that figured for *A. maculatus gularis* (fig. 2A).

In the majority of species the ischio-pubic fenestra is divided by a strong cartilaginous structure involving both the hypo-ischium and the epipubis. In *T. lineata, T. tetraporophora, T. maculosa* and *A. adelaidensis* this median structure is heavily calcified throughout (see fig. 2), but in *A. maculatus gularis, A. reticulatus inermis, A. cristatus, A. fionii* and *A. decresii* calcification only occurs at the pubic and ischial ends. In *T. cephalus gigas, T. intima,* and *A. diemensis* the ischio-pubic fenestra is not completely divided.

The pubis is pierced by an obturator foramen, but because of the shape of the pubic bones this is partly or completely obscured in some species. When the girdle is viewed ventrally, the anterior process is transversely compressed and curves upward and outward in the form of a prepubic lip, on the lateral end of which is attached a ligament connected obliquely across to a point on the corresponding ischium. In species in which the process is strongly compressed and the lip well developed—*T. intima, T. lineata, T. tetraporophora, T. maculosa* and *A. adelaidensis* the obturator foramen is directed forward. In *T. intima* the foramen is directly below and completely concealed by the prepubic lip (see fig. 2). Of the species of *Tympanocryptis, cephalus gigas* is the only species examined which does not possess this feature. It possesses a very narrow girdle with the obturator foramen situated well below and across from the prepubic lip, being clearly visible when the girdle is viewed squarely from below.

Limb Structure: The structure of the forelimb was found to be constant, the primitive reptile formula of 2,3,4,5,3 being retained for the manus of all species examined.

Examination of hindlimb structure revealed the only clearly definable dichotomy evident from this study. All species of *Amphibolurus* examined possessed the primitive 2,3,4,5,4, formula for the pes while all species of *Tympanocryptis,* except *maculosa,* show a reduction of one phalanx in the fifth toe to a formula of 2,3,4,5,3. *T. maculosa* retains the primitive formula for both manus and pes.

There does not appear to be any significant variation in tarsal or carpal structure. The astragalus and calcaneum are fused in adults, but the suture is frequently distinct. These two bones are separate in juveniles of *T. maculosa.*

Vertebral Column: The number of presacral vertebrae (including the atlas) varies from 21 to 24 (see also Mitchell, 1948). The majority of species possess twenty-two, but the following exceptions were noted. *T. lineata* (21 and 23), *T. tetraporophora* (21 and 23), *A. adelaidensis* (21 and 23), *A. cristatus* (23) and *A. reticulatus inermis* (24).

The atlas has paired neurapophyses which are widely separated in most species. All presacral vertebrae except the atlas and three cervicals have ribs attached. There is much variation in the relative size and form of the neural spines, the spines being conspicuously

larger in long-limbed species possessing "open" type pelvic girdle structure (see fig. 2A) such as *A. maculatus gularis* and *A. cristatus*. This may be related to their ability to adopt a bipedal mode of locomotion.

DISCUSSION

Of the features examined, only the hindlimb structure shows a definable dichotomy which can be clearly correlated with taxonomic characters currently in use. The variation in all other features shows varying degrees of overlap between species in the two genera.

To further assist in determining the stability of the phalangeal structure, two unique specimens in the South Australian Museum collection were radiographed. The holotype of *T. uniformis* Mitchell, which is superficially unlike any other member of the genus, was photographed under X-rays and proved to be typical of the genus. It has a reduction of one phalanx in the fifth digit of the pes. A small dragon collected at the Silverband Falls, Grampians, Victoria and registered No. R3294 in the South Australian Museum collection shows close superficial similarity in size, scalation and colouration to *T. lineata* Peters, but differs in possessing a tympanic membrane which is only partially concealed and in having four or five femoral pores on each side. The whole membrane appears to be covered by a thin veneer of epidermal tissue, the central and upper parts of which are thickened, scaly and pigmented to match the surrounding epidermis. The radiograph of this specimen revealed no reduction in the number of phalanges of either manus or pes.

The support of *T. uniformis* leaves no doubt that the reduction of one phalanx in the pes in combination with the external features currently used to delimit *Tympanocryptis* will serve to maintain it as a useful taxonomic unit. Whether or not it is safe to assume a monophyletic origin for the species so grouped must remain a matter of opinion until more is known about the interspecific stability of osteological characters in this family.

Hypophalangy has been recorded as a species character in other families. Stephenson (1960) records variation in the formulae for both manus and pes in two species of the genus *Nephrurus* (Gekkonidae); Mitchell (in press) records the loss of one phalanx in the manus of a species of *Diplodactylus* (Gekkonidae); Mitchell (1955 and unpublished data)—progressive hypophalangy in both manus and pes is an important aspect of speciation in the Scincidae.

The discovery of a further species of *Amphibolurus* obviously not closely related to the progenitors of *maculosa,* which is developing a close resemblance to *Tympanocryptis* including a scaly covering for the ear membrane suggests that this feature is a recent and secondary development.

Within the range of variation recorded, *Tympanocryptis* species lie near one extreme and are subject to less interspecific variation. Features usually combined, such as the strong development of the bones in the superior temporal arch, the enlargement and interlocking of the conical anterior teeth, the short, wide, arrow-shaped interclavicle and the form of the pelvic girdle are characters developed independently in *Amphibolurus* species.

The species *maculosa* agrees with *Tympanocryptis* in dentition, pelvic girdle structure and concealment of the tympanum, but is typical of short-limbed species of *Amphibolurus* in all other respects. It is therefore proposed that *maculosa* be regarded as a specialized member of that genus. As such it would become *Amphibolurus maculosus* (Mitchell). The closeness of the specific names *maculosus* and *maculatus* is regrettable, but both appear to be admissible under the International Rules of Zoological Nomenclature.

ACKNOWLEDGMENT

I am grateful to Dr. N. Ballai for his assistance in radiographing the two specimens referred to in discussion and to my assistants, Miss Lois Jaques for her assistance in the preparation of the illustrations and much of the material examined, and to Miss Patricia Muggridge for the typing of the manuscript.

RESUME

Dans ce travail on traite et illustre l'anatomie de l'esquellette de l'agamide *Tympanocryptis maculosa* Mitchell (1948). Comme resultat des comparisons faites entre cette espèce et autres des genres *Tympanocryptis* et *Amphibolurus* on transfère *maculosa* au *Amphibolurus.*

REFERENCES CITED

Beddard, F. E., 1905: A contribution to the Anatomy of the Frilled Lizard (*Chlamydosaurus kingi*) and some other Agamidae. Proc. Zool. Soc. Lond. 1: 9.

Mitchell, F. J., 1948: A Revision of the Lacertilian Genus *Tympanocryptis*. Rec. S. Austr. Mus. IX: 57-86

——— 1955: A Preliminary account of the Reptilia and Amphibia collected by the National Geographical Society-Commonwealth Government-Smithsonian Institution Expedition to Arnhem Land. Rec. S. Aust. Mus. XI: 373-408.

——— (in press): Australian Geckos assigned to the Genus *Gehyra* Gray (Lacertilia: Gekkonidae).

Peters, W., 1863: Monatsb. Akad. Wiss. zu Berlin: 230.

Stephenson, N. G., 1960: The Comparative Osteology of Australian Geckos and its bearing on their morphological status. Journ. Linn. Soc. Lond. Zool. XLIV: 247-299.

AN OCCURRENCE OF SELENITE NEAR WHYALLA, SOUTH AUSTRALIA

By DAVID W. P. CORBETT, Curator of Fossils and Minerals, South Australian Museum

Fig. 1-4

SUMMARY

A recently discovered occurrence of crystallized gypsum in South Australia is described, and a wide variety of crystal forms defined. Interim results of field and laboratory investigations currently being undertaken are given, together with chemical analyses of saline water samples. The general environment of the occurrence and the origin of the gypsum are discussed.

INTRODUCTION

Two small saline waterholes in an otherwise dry creek bed some 20 miles north-east of Whyalla were discovered by Mr. Barry Whittard of Whyalla, in February, 1962. The waterholes contained numerous crystal groups of the mineral gypsum var. selenite, $CaSO_4.2H_2O$. Further investigations of the occurrence were made by Mr. Whittard in the company of Mr. B. Flounders, also of Whyalla. Several specimens were collected and some of these presented to the South Australian Museum by Flounders.

Since December 1963, a joint investigation has been carried on by Flounders and the South Australian Museum into the origin of the gypsum at this unusual locality. Except for the removal of a representative collection for scientific purposes, the pools have been left in their original state and used as a natural laboratory. In this paper the site will be referred to as the Lincoln Park locality. The locality is shown on fig. 1.

DESCRIPTION OF THE OCCURRENCE.

The two waterholes under consideration appear to be permanent features in a shallow creek channel which terminates in a saltpan. The two waterholes, henceforth referred to as the upper and main pools, are found immediately below a breakaway in the channel, and are bounded by banks four to six feet high.

The dimensions of the pools are:—Upper pool—30 yards by 3 yards, average depth 6 inches: Main pool—30 yards by 3 yards, average depth 2 feet. A general view of the locality is shown in fig. 3A.

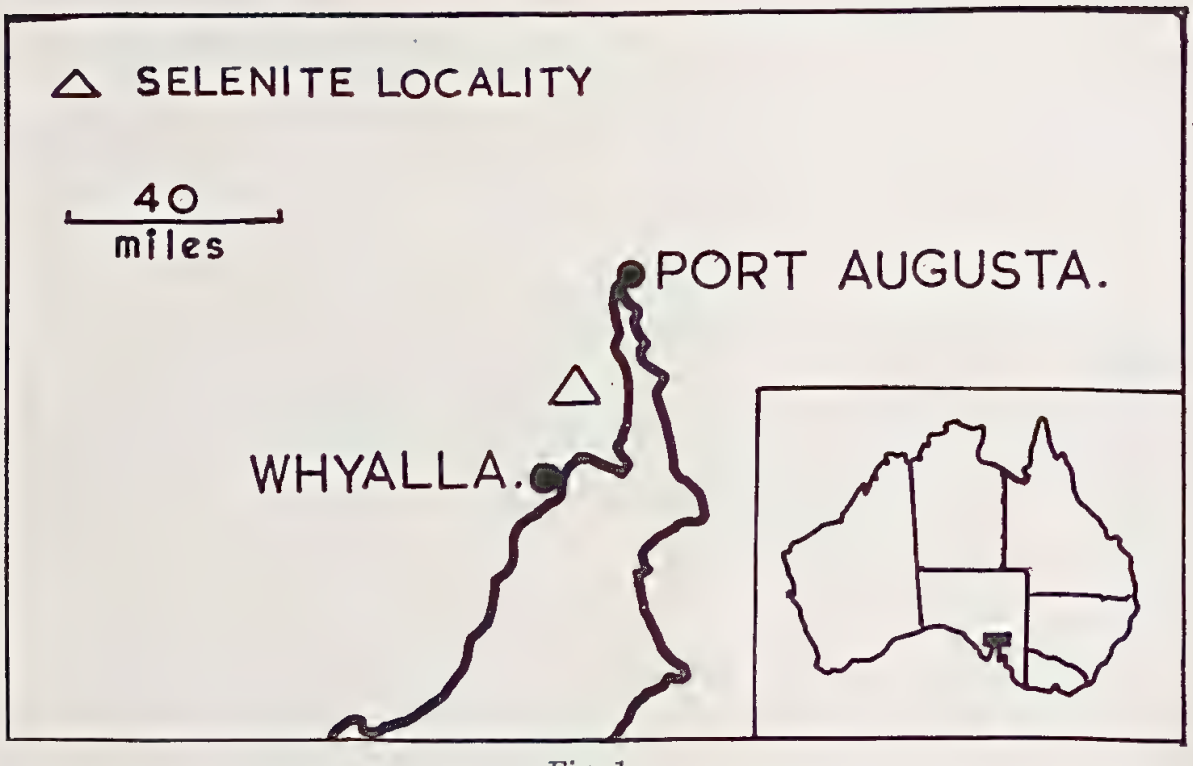


Fig. 1.

Crystallization is concentrated around the margins of the pools, with a prominent shelf developed below water level (see fig. 3B). Twigs and dead branches have frequently formed centres for crystallization. In the centre of the main pool, islands of gypsum have formed over the carcasses of two sheep. A test pit sunk between the two pools to a depth of 6 feet revealed a mass of thick, bladed crystals growing in mud. Infilling water prevented excavation to greater depth.

The Classification of the Gypsum Crystal Forms

Gypsum crystals are found in three different environments at Lincoln Park—in mud, in water and in air. The various forms developed can be classified as follows:—

1. *Crystals in mud.*
   a. Thick-bladed groups (fig. 3C).
   b. Layered groups (fig. 3D).
   c. Desert rose form (fig. 4B).
   d. Transitional groups.
2. *Crystals in water.*
   a. Bladed clusters (fig. 4A).
   b. Rosettes and pompoms (fig. 4C).
   c. Individual crystals on vegetation (fig. 4C).

3. *Crystals in air.*
   a. "Coralline" gypsum (fig. 4D).

Description of Crystal Forms

1a. *Bladed groups*: These include the largest individual crystals found (up to 15 inches in length). All the well-developed crystals have grown in an upright position. The development of secondary and tertiary crystals results in a crude reticulate pattern, the largest, and primary crystals forming the basic framework. In almost all cases the large bladed crystals show strong evidence of re-solution, having ragged terminations and corroded edges. The bladed crystal groups are generally free from impurities, but have a milky appearance due to entrapped air.

1b. *Layered crystal groups*: The layered structure is clearly the result of a cyclic growth which is probably seasonal. In the figured specimen, six crystal layers have developed in a block 6 inches deep. The average thickness of each layer is 1 inch. When the layering is well developed, the vertically disposed crystals are capped by a thin mat of finely crystallized gypsum which is in turn succeeded by a further layer of vertical laths. This is well shown by the bottom layer in the figured specimen. The upper layers are coloured brown by the inclusion of impurities. Colour zoning is shown by some of the larger crystals.

1c. *Desert rose groups*: These are well developed in the creek bed about half a mile south of the Lincoln Park pools. Single lens-shaped crystals have developed by the enlargement of the 011 face and the suppression of the 010 face. These faces are frequently curved.

1d. *Transitional groups*: The largest single specimen taken from the Lincoln Park pools measures 19 inches by 10 inches and consists of clusters of thick, vertically disposed, bladed crystals, the whole having a rough stratification. The bottom layer is composed of clear crystals developed in mud; the second layer is of impure brown-coloured crystals grown in water; and the top layer shows a development of the coralline gypsum grown at about water level.

2a. *Bladed clusters*: These may have their origin in mud or upon twigs and dead vegetation blown into the pools; however the major part of their growth has taken place freely in water. They are most often stained a yellowish-brown due to the inclusion of impurities.

2b. *Rosettes and pompoms*: These forms are found growing on pieces of vegetation and include the most beautiful of the crystal groups developed. In the rosettes, crystallization has proceeded

outwards from a point, producing a series of radially arranged lath-shaped crystals. Pompoms are smaller groups, where there has been a close packing of the crystals to produce a compact crystal mass.

2c. *Single Crystals*: These occur growing on dead twigs in the manner of leaves upon a tree.

3a. *"Coralline" gypsum"*: This is the name given to milky-white crystalline material developed close to the surface of the water and readily exposed to the air with a slight fall in water level. Under magnification this form is seen to consist of small, fine laths of radiating crystals massed together.

INVESTIGATION OF THE OCCURRENCE

Investigations have been directed along the following lines:—

1. Setting up and maintenance of test pits at the site for the controlled growth of gypsum crystals.
2. Experimental studies of gypsum crystal growth in glass tanks.
3. Analysis of saline waters for dissolved salts and pH measurement of pool and ground waters in the field and in the laboratory.
4. A study of the natural environment of the gypsum site.

These points will be treated in turn.

1. *Test pits*: Three pits approximately 5 feet by 3 feet were dug within the creek bed adjacent to the two pools. Their positions are shown on fig. . Each was seeded with pieces of vegetation and gypsum crystals to act as centres for crystallization. The pits were covered with wire netting to prevent the entry of extraneous matter.

Within three weeks of establishing the test pools, fine, needle-like crystals up to three-eighths of an inch long were noted forming on vegetation in the lowermost pit. Further developments in the test pits were retarded by the unexpected rise of the water table. At its height this rise caused flowage down the creek bed two-thirds of the distance to the salt pan, and the newly formed crystals in the test pit were re-dissolved. The water table remained high until October 1964, when a drop in level and a cessation of flow has resulted in the renewal of crystallization in the pools and test pits.

The summer of 1963-64 was one of the driest for 30 years, so that the marked rise of the water table can be taken to be a lag effect from the heavy rains of the previous winter, which caused a flooding of the neighbouring creek.

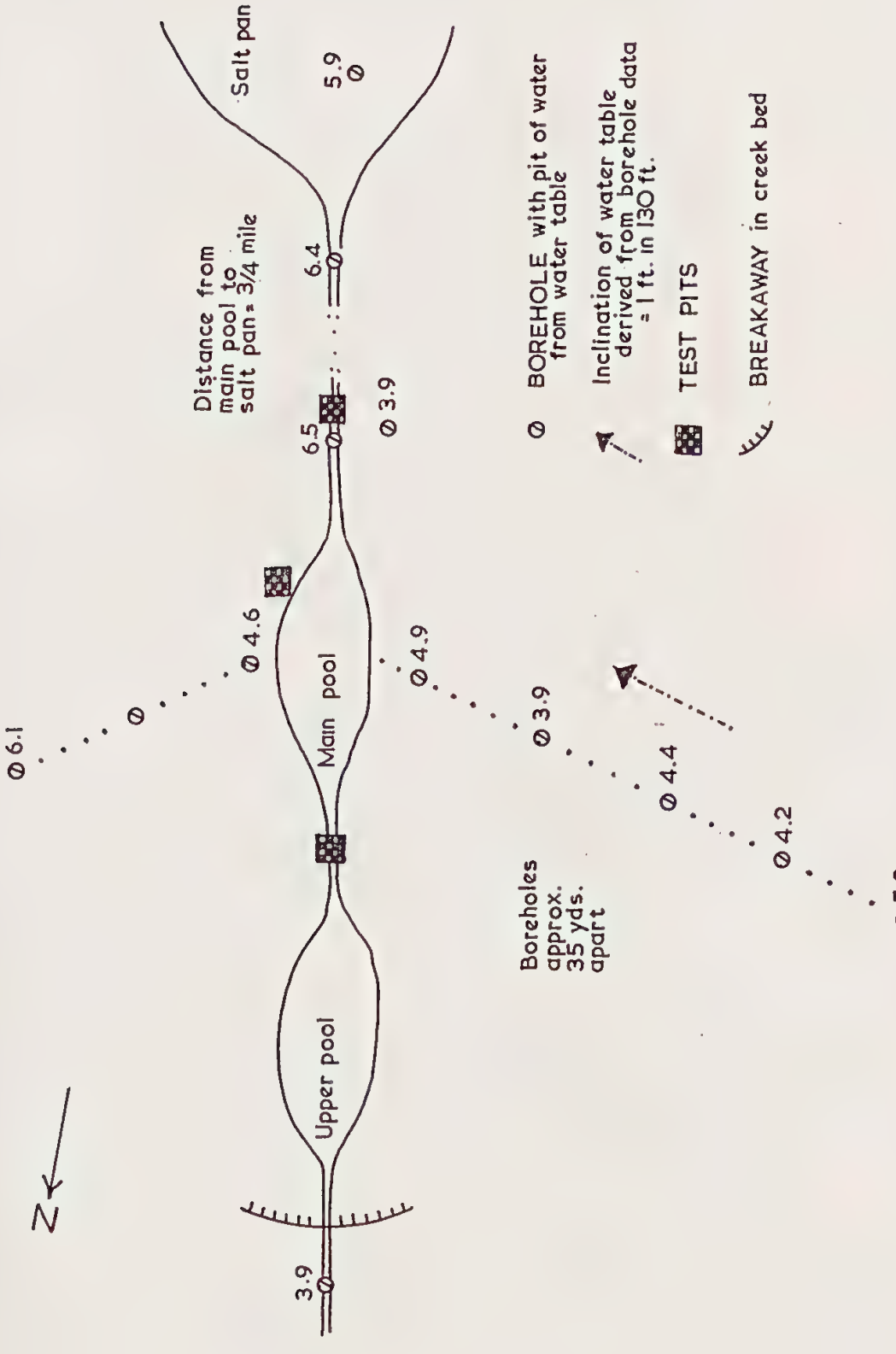


Fig. 2. Sketch Plan showing location of bore holes with pH of water from water-table.

2. *Experimental tank studies*: These have been carried out by B. Flounders using both natural saline waters and also prepared solutions of varying composition. Tests were conducted on the solubility of gypsum in salt solutions of different densities. The results of experimental work to date can be summarized as follows:—

(*a*) Greatest success has been achieved in growing gypsum crystals from the natural water from the Lincoln Park locality. Crystallization from prepared waters has been almost entirely "seed" gypsum found settling on the bottom of the tank.

(*b*) Crystallization rates were noted during the experimental work. Increases in excess of one grain per day have been recorded, supporting the view that crystallization of gypsum under natural conditions can proceed rapidly in a suitable environment.

(*c*) In all cases where a small crystal of a certain type was used as a seed, crystallization followed the same pattern. For example a bladed crystal would continue to develop the bladed form.

(*d*) Problems of duplicating the natural environment in a glass tank were probably the cause of difficulty in producing crystal groups similar to those formed in nature. Factors to be considered include circulation of water, surface turbulence due to wind and currents, and the effect of mud and dust.

(*e*) A more elaborate tank is at present being constructed in which it will be possible to maintain a flow of water and regulate the physico-chemical conditions to simulate a variety of environments.

(*f*) It has been noted that gypsum readily crystallizes on organic substances in the tank experiments, for example on the inside of a plastic bucket, on a nylon line, and on vegetation as in the natural environment. Crystallization does not take place on the sides of the glass tank or on rock surfaces.

3. *Analysis of saline waters*: The analyses of four water samples from Lincoln Park are given in table 3 and compared with an analysis from a water bore in the same region. (This is the only bore water analysis available for comparison.) Unexpectedly, the Lincoln Park waters are all highly acid, with a pH range of 2.95 to 4.15. Field tests carried out in the area on both pool and water table samples confirmed these results. The field results are plotted on fig. 2 and

indicate a local concentration of the acid waters in the vicinity of the two pools. However, a pH of 2.0 obtained from a ground water sample taken from a salt pan in the Kimba Gap area, 25 miles S.W. of Whyalla, suggests that local concentration of highly acid waters may be expected in the region. For comparative purposes pH readings made on ground water samples from similar environments in South Australia are given in table 1.

TABLE 1

pH of Some South Australian Natural Waters.

Locality.	pH.
Gypsum pools, Lincoln Park	2.4-4.15
Lake Bumbunga, Lochiel	6.0
Salt pan, south of pools, Lincoln Park	6.6
Water from gypsum stalactite, Murray River cliffs, Waikerie	6.8
Salt Flat, near rifle range, Whyalla	7.0
Myall Creek, near Lincoln Highway crossing	7.1
Sea water, Hallett Cove	8.1

THE GEOLOGICAL ENVIRONMENT OF THE LINCOLN PARK GYPSUM OCCURRENCE

The area is included in the Geological Survey of South Australia 1:36630 sheet, Cultana, and is underlain by siltstones and sandstones of Proterozoic age. An area of igneous rocks occurs to the eastward. Drainage in the area is derived from the watershed formed by the flat-lying quartzites of the Tent Hill Formation which are elevated to a height of 912 feet at Tregolana triangulation station. The oldest sedimentary rocks in the area, the Moonabie Formation, are notable for the prevalence of heavy mineral banding and the inclusion of nodular iron oxide.

It is of interest that in the Katunga Hills boreholes described by Miles (1954), iron sulphides were encountered at depth. In borehole No. 1 pyrite appears at 380 feet, and both pyrite and pyrrhotite are more plentiful below 1,000 feet. In borehole No. 2, pyrite occurs at 226 feet, pyrrhotite increasing below 600 feet. The sulphides are described as metasomatic replacement deposits, particularly intense mineralization occurring along formation boundaries.

The structure of the northern part of Eyre Peninsula is controlled by a series of roughly north-south trending faults. Although these were initiated at an earlier date, the latest movement along these faults was probably of Pliocene or Pleistocene date. Within the Cultana sheet area, a distinct fault scarp marks the margin of the outcrop of the Tregolana Formation. It is possible that other faults are present in the area, but are obscured by recent deposits.

CHEMICAL CHARACTERISTICS OF SUB-SURFACE WATERS

Little information is available regarding the acidity and alkalinity of sub-surface waters in South Australia. The chemical characteristics of waters in the Great Artesian Basin have been described by Jack (1923) and discussed by Ward (1946). Jack recognized an easterly derived carbonate water and a westerly derived sulphate water moving towards their natural outlet along the line of mound springs. A pH reading of 8.95 is quoted by Baas Becking and Kaplan (1956) from a bore in the Lake Frome area. This bore is situated in the region of the carbonated waters. The sulphate waters of the western section of the basin can be expected to have a lower pH. The brines and muds from Lake Eyre are almost neutral, having a pH range of 6.6 to 7.2 (*ibid* 1956).

The Lincoln Park waters are closely comparable with sea water in chemical composition, and the comparison is made in table 2. Their high calcium content is due to the solution of the surface kunkar limestone.

TABLE 2

Percentage of Major Dissolved Constituents.

	Sea water*.	Water-table, Lincoln Park.	Brine, Lake Eyre.
Cl	55.05	53.97	57.00
SO_4	7.68	8.37	4.00
Na	30.61	30.31	35.67
Mg	3.69	2.94	1.33
Ca	1.16	4.31	0.31
	98.19	99.90	98.31

Dissolved Constituents—Parts Per Thousand.

	Sea water†.	Water-table, Lincoln Park.	Brine‡, Lake Eyre.
Cl	18.980	17.269	171.000
SO_4	2.649	2.683	12.000
Na	10.556	9.700	107.000
Mg	1.272	0.940	4.030
Ca	0.400	1.385	0.950

* From Mason, B. H., *Principles of Geochemistry*, John Wiley and Sons, London.
† From Rankama and Sahama, *Geochemistry*, University of Chicago Press.
‡ From Baas Becking and Kaplan (1956).

ORIGIN OF THE GYPSUM

The deposition of the remarkable crystal groups at Lincoln Park must be attributed to local physical and chemical factors. In particular there is a direct causal relationship between the high acidity of the gypsum pools and the crystal growth. Highly acid waters (ph less than 4) have a restricted occurrence, being confined to thermal springs in regions of recent volcanicity; peat soils; and areas where H_2SO_4 is generated by the oxidation of sulphide deposits. The first two possibilities can be ruled out for the region under review, which fulfills

neither of the necessary conditions. The third possibility, however, deserves consideration.

No evidence of sulphide mineralization is found at the surface in the area. However, the presence of pyrite and pyrrhotite in the Katunga Hills boreholes is of interest, and it is conceivable that similar metallic sulphides could exist at depth below the Lincoln Park locality, and that their oxidation has resulted in the formation of sulphuric acid. The reactions involved are as follows:—

$$FeS_2 + 7O + H_2O = FeSO_4 + H_2SO_4$$
$$2FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O$$
$$Fe_2(SO_4)_3 + 6H_2O = 2Fe(OH)_3 + 3H_2SO_4$$

Upward migration of acid-charged waters could have taken place along a fault line, several of which are known to occur in the region. The surface or near surface kunkar limestone could supply the calcium necessary to produce gypsum according to the formula:

$$CaCO_3 + H_2SO_4 = CaSO_4 + H_2O + CO_2$$

The present water table stands only a few feet below ground level, so that oxidation must have taken place at a time when the water table was lower, or alternatively aerated waters gained access along the fault line and caused oxidation below the general level of the water table.

TABLE 3

Water Analyses from Lincoln Park Gypsum Locality.

	Main pool.	Upper pool.	200yds. downstream from main pool.	Water table between upper and main pools.	Water bore, Hd. of Gillen 6m. N.N.W. of Lincoln Gap Homestead.
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
Chloride Cl	35,725	57,410	105,200	17,269	5,856
Sulphate SO_4 . ..	5,068	6,880	6,400	2,683	1,302
Carbonate CO_3 ..	Nil	Nil	Nil	8	284
Nitrate NO_3 . ..	Nil	Nil	Nil	Nil	—
Sodium Na	20,330	31,935	57,630	9,700	3,029
Potassium K . ..	—	—	—	—	
Calcium Ca	1,882	1,905	1,925	1,385	605
Magnesium Mg ..	2,075	3,390	6,055	940	484
Silica SiO_2	—	—	—	—	—
Total saline matter	65,080	101,520	177,210	31,985	11,560
Assumed composition of salts:					
Calcium carbonate	—	—	—	13	474
Calcium sulphate .	4,692	6,465	6,545	3,420	1,410
Magnesium sulphate	2,830	2,907	2,230	806	384
Magnesium chloride	5,883	10,978	21,945	3,043	1,593
Sodium chloride ..	51,675	81,170	146,490	24,703	7,699
	pH 3.55	pH 2.95	pH 3.55	pH 4.15	pH 7.00

CONCLUSIONS

The water in the Lincoln Park gypsum pools is essentially sea water modified by a slight increase in the sulphate ion and the addition of calcium locally derived from the surface and near surface

kunkar limestone. The cause of the high acidity of the Lincoln Park waters has not been determined, although one possibility has been suggested in this paper. It is considered that the high acidity has been the direct cause of the gypsum crystallization at Lincoln Park. The apparently continuous formation of gypsum, together with the relatively low concentration of the sulphate ion in the analyses quoted, indicates that sulphate is being continually replenished.

Evidence from the Kimba Gap area shows that gypsum formation in a highly acid environment is not restricted to the Lincoln Park locality. The physico-chemical environment at Lincoln Park is, however, very different from that in which gypsum is normally found in South Australia. The conditions described are local and unusual, and the extent of the area in which these local conditions can be found is unknown, but their development may be related to the surface and sub-surface geology of the region. It is hoped that further studies on a regional scale may help to resolve this problem.

ACKNOWLEDGMENTS

The author wishes to thank Mr. Ben Flounders of Whyalla, the instigator of the gypsum project, for the important part he has played in the work. On his shoulders has devolved the major part of the field work, and his never-flagging enthusiasm has in large measure ensured the continuity of observation which is so necessary in a project of this kind. His stimulating views on the gypsum problem have been a continued source of inspiration.

Thanks are also due to Mr. Barry Whittard and Mr. Peter Flounders for their help in the field, and to Mr. Len Hese for the transport of specimens from Whyalla to Adelaide on numerous occasions.

The chemical analyses of the Lincoln Park waters were carried out by the Australian Mineral Development Laboratories, Parkside, South Australia, and their assistance is here acknowledged.

REFERENCES

Baas Becking, L. G. M. and Kaplan, I. R., 1956: The Microbiological Origin of the Sulphur Nodules of Lake Eyre. Trans. Roy. Soc. S. Aust., 79, pp. 52-64.

Jack, R. L., 1923: The Composition of the Waters of the Great Artesian Basin in South Australia and its significance. Trans. Roy. Soc. S. Aust., 47, pp. 316-321.

Miles, K. R., 1954: The Geology and Iron Ore Resources of the Middleback Range Area. Geol. Surv. S. Aust. Bull. No. 33.

Ward, L. K., 1946: The Occurrence, Composition, Testing and Utilisation of Underground Water in South Australia, and the Search for further Supplies. Geol. Surv. S. Aust. Bull. No. 23.

EXPLANATION OF FIG. 3-4

FIG. 3

A. General view of the Lincoln Park gypsum site looking south-east. Main pool in the foreground.

B. The edge of the main pool showing the development of the underwater shelf of bladed crystal groups. Coralline gypsum above the water level.

C. Group of thick-bladed crystals. Maximum length of group 15 inches.

D. Layered group. Thickness of the block 6 inches.

FIG. 4

A. Bladed cluster. Much of the gypsum forming the underwater shelf is of this type. Height of specimen 7½ inches.

B. Desert rose gypsum grown in mud. (Natural size.)

C. Crystal rosette growing on vegetation. Individual crystals of common form occur at the right of the photograph. Length of specimen 5½ inches. Inset shows the pompom type of crystallization. (Natural size.)

D. "Coralline" gypsum developed on a mat of small pompoms. Length of specimen 6 inches.

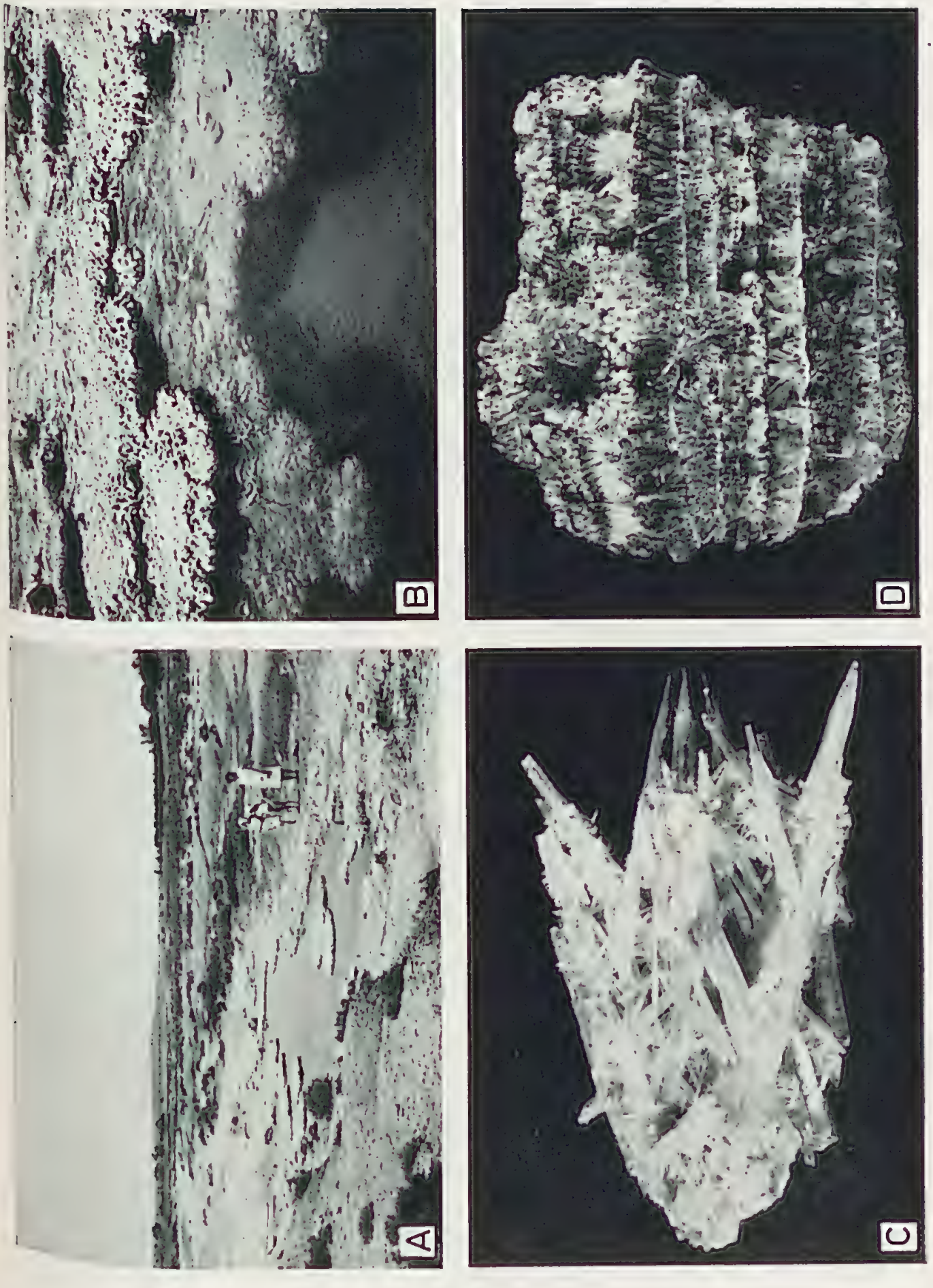


Fig. 3.

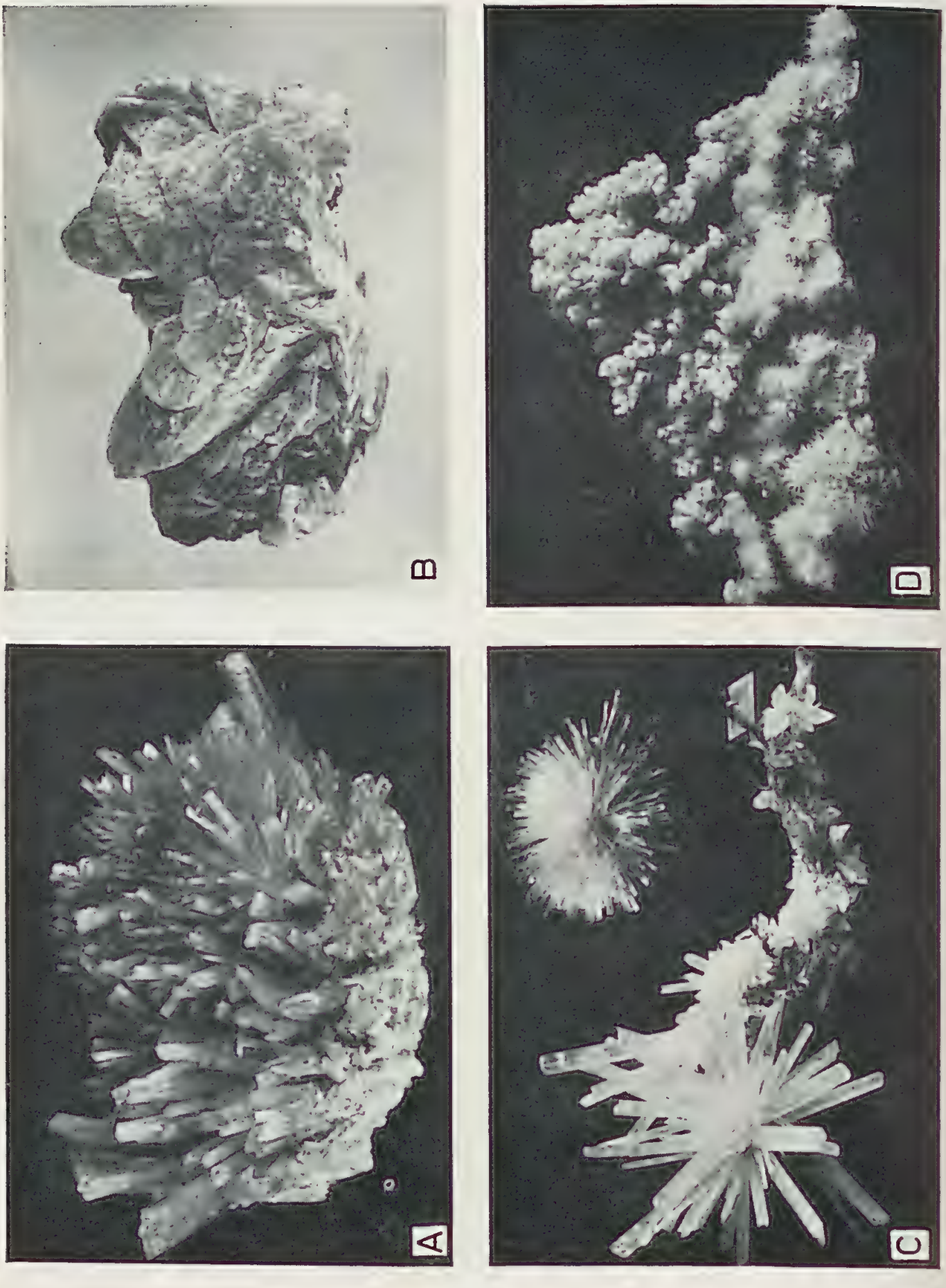


Fig. 4.

NEW SPECIES OF OLOGAMASUS BERLESE (ACAR: RHODACARIDAE) FROM AUSTRALIA AND NEW ZEALAND

By DAVID C. LEE, Curator of Arachnology, South Australian Museum

Text fig. 1-54

SUMMARY

Ologamasus Berlese, is re-defined and considered to be closely allied to *Gamasellus* Berlese. A key is given for identification of the known adults of 12 new species of *Ologamasus* (*O. cymosus, mansoni, leptosceles, dumosus, mucilis* and *validus* from New Zealand, and *O. pyrenoides, discutatus, litoprothrix, tindalei, southcotti* and *virgosus* from Australia) which are described in three groups.

INTRODUCTION

The limits of the Rhodacaridae are uncertain, but Evans (1963) pointed out that, on the basis of leg chaetotaxy, it contained a natural assemblage of genera which he termed the *Rhodacarus*-group. Genera of the *Rhodacarus*-group occur in both of the subfamilies that Ryke (1962a) separates on the structure of the adult dorsal shield; which is entire in the Ologamasinae and divided in the Rhodacarinae. Since I consider that the mites described in this paper belong to *Ologamasus* and are closely allied to *Gamasellus,* which is placed in the Rhodacarinae, I have had to disregard these subfamilies. Instead, I have separated off some of the genera of the *Rhodacarus*-group, that are listed below, by the form of their dorsal setae. This character has been used by Evans (1957) to separate *Cyrtolaelaps* and *Eurypara-situs.* To apply it, as a diagnostic character to divide the *Rhodacarus*-group of genera into two groups, is unsatisfactory and it is used here only as a temporary measure. It splits *Gamasellus* into two groups and leaves only *Ologamasus aberrans,* of the previously described species, in *Ologamasus.*

The following genera of the *Rhodacarus*-group contain species with one or more pairs of obviously pilose or paddle-like setae on the dorsal shield:—

Cyrtolaelaps Berlese, 1887. Ryke (1962b) lists as a subgenus of *Cyrtolaelaps* sens. lat.

Gamasellus Berlese, 1892 (in part). Ryke (1962b) lists as a subgenus of *Cyrtolaelaps* sens. lat.

Gamaselliphis Ryke, 1961. Subgenus of *Cyrtolaelaps* sens. lat.
**Periseius* Womersley, 1961.
**Heterogamasus* Trägårdh, 1907.
Evanssellus Ryke, 1961.
Ologamasus Berlese, 1888.
**Euepicrius* Womersley, 1942.
**Stylogamasus* Womersley, 1956.

* = genus not listed as belonging to Rhodacaridae by Ryke (1962a).

Of the genera listed above, *Ologamasus* and those listed before it may be closely allied, while the position of *Euepicrius* and *Stylogamasus* is uncertain.

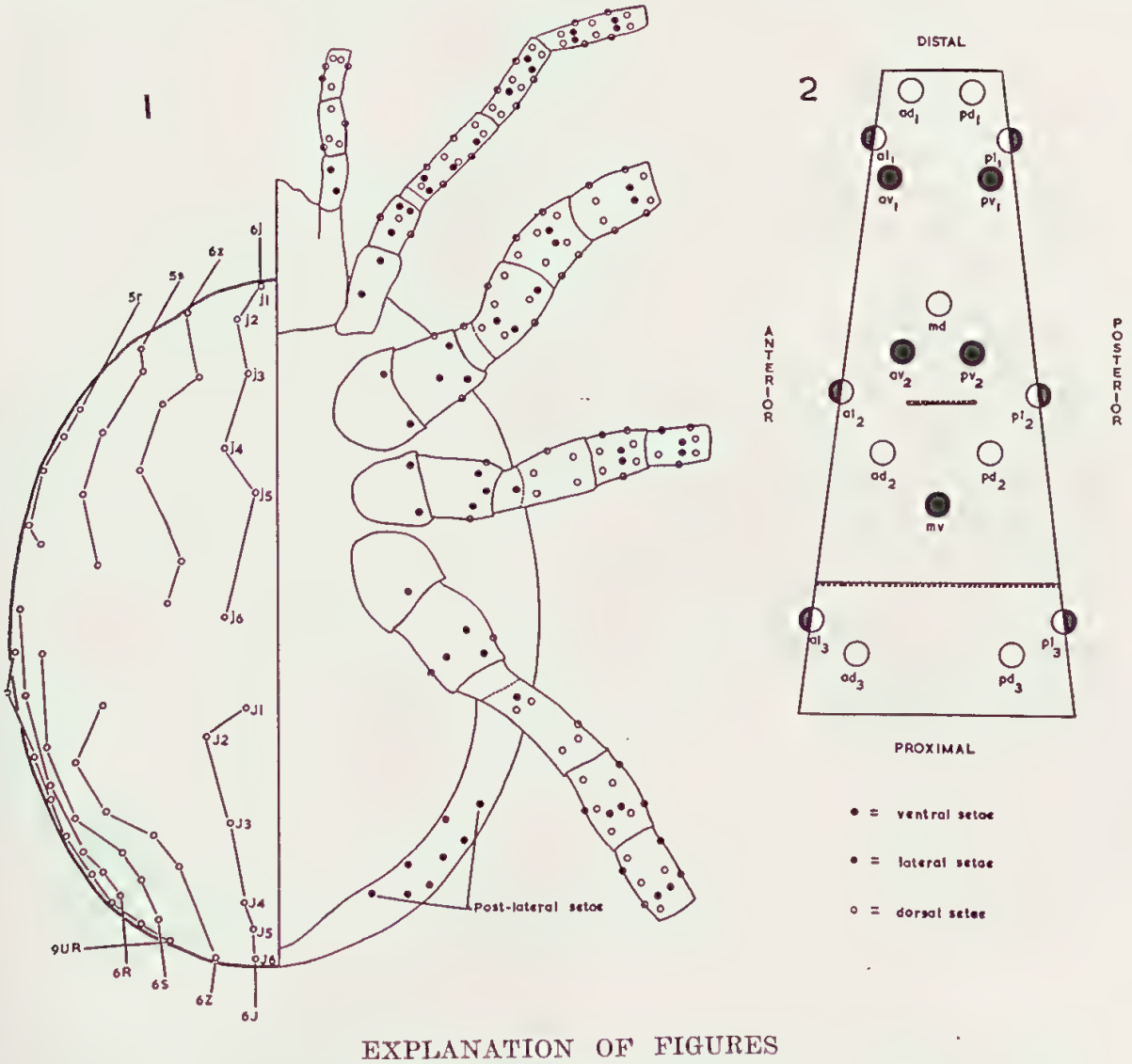
There are four species from Argentina, previously in *Ologamasus* (*O. coleoptratus* Berlese, 1888; *O. simplicior* Berlese, 1914; *O. striolatus* Berlese, 1916 and *O. cavei* Sheals, 1962), that are excluded by this paper. I have examined *O. cavei* type material and its undescribed male, as well as specimens which may be *O. simplicior,* and consider that they have affinities with South American and Australian "*Hydrogamasus*". Since these "*Hydrogamasus*" are not congeneric with *Hydrogamasus salinus* Laboulbène, 1851, but appear to be more allied to *Parasitiphis littoralis* Womersley, 1956, I would temporarily place the above species in *Parasitiphis.* These relationships are confused but, if the *Gamasiphis* I have examined are congeneric with *G. pulchellus* Berlese, 1887, it is certain that the above species do not belong to *Gamasiphis,* which differs, among other characters, in having a reduction in the number of setae on genu III and IV.

MATERIAL AND METHODS

The mites belonging to *Ologamasus* are from New Zealand and Australia, and were extracted from moss and litter by using desiccating funnels. They have been mounted in either a gum chloral medium or in lactic acid, before being drawn with the aid of a camera lucida. The use of two methods of mounting means that the specimens were squashed in varying degrees. The distortion of squashed specimens is mainly lateral and the effect can be seen by comparing fig. 36 and fig. 42, which are of mites of about the same shape.

The following type material has been deposited outside the South Australian Museum, Adelaide. Female and male paratypes of *Ologamasus cymosus* and *pyrenoides,* and male paratype of *O. discutatus,* at the British Museum (Natural History), London. Female and male paratype of *O. cymosus* at the Dominion Museum, Wellington. Female and male paratype of *O. pyrenoides* at the Natal Museum, Pietermaritzburg.

The terminology generally is that of Evans (1957), except that *apotele* is used instead of palptarsal seta and *spermodactyl* instead of spermatophoral process. The position of *post-lateral setae* is shown on fig. 1. The terminology for leg and pedipalp chaetotaxy is that of Evans (1963 and 1964), see fig. 1 and 2. The terminology for dorsal chaetotaxy merely approximates to that of Lindquest and Evans



EXPLANATION OF FIGURES

Fig. 1-2. Diagrammatic representation of the chaetotaxy of *Ologamasus discutatus* sp. nov. female.

Fig. 1. Dorsum. post-lateral setae and basal segments of palp and leg.
Fig. 2. Tarsus of legs II, III or IV.

(1965), since I know of this paper only through correspondence with Dr. Evans. One certain difference is that I have numbered the setae of each dorsal row as if that species had a complete series; see fig. 1. The single measurement given is the length of the idiosoma of the mounted holotype, allotype or morphotype, to the nearest 10μ.

Family RHODACARIDAE Oudemans, 1902.

Genus **Ologamasus** Berlese, 1888, *nec* Berlese, 1906.

Syn: *Ologamasellus* Berlese, 1914.

Type: *Ologamasus aberrans* Berlese, 1888.

The following characters of the genus place it in the *Rhodacarus*-group. The leg chaetotaxy is of the type in which the setal formula of tibia I is (2-6/4-2). The apotele is three tined, with one tine reduced and without an associated hyaline flap. In the female the metasternal setae are on the sternal shield, and the genital shield is truncated posteriorly and separate from a ventrianal shield. In the male the genital orifice is presternal, and there is a distally free spermodactyl and an armed leg II.

Within the *Rhodacarus*-group, *Ologamasus* is limited to the list of genera given in the above introduction by the presence of obviously pilose setae on the dorsal shield, it is separated from all the genera listed before it and from *Euepicrius* by having an entire dorsal shield in the female and usually in the male also. It can be separated from *Stylogamasus*, which has an entire dorsal shield in the adult, by having the sternal shield separate from endopodal shields IV in all species that have the ventrianal shield separate from the dorsal shield, and also by the ventral setae on the genu and tibia of legs III and IV not being pilose.

There are a number of characters, not mentioned above, which occur in all, or most, of the adults of the genus. The denticles on the deutosternum are not always very clear, but they appear to be in six or seven transverse rows and never nine rows as in *Cyrtolaelaps* and *Euryparasitus*. The idiosoma is strongly convex dorsally and well covered with sclerotized shields. Most species seem to have produced a sticky exudation, similar to that of some Crytostigmata, which may cover a lot of the opisthosoma and have dirt and fungal hyphae adhering to it. The degree of fusion of the shields is very variable, but the peritrematal shield always merges with the dorsal shield anteriorly and exopodal shields IV posteriorly. The sternal shield is always fused to endopodals II. In the female there is a crescent shaped, endogynial shield fitting into the posterior concavity of the sternal shield and the anterior margin of the genital shield is thin and almost hyaline. The chaetotaxy of genu III and IV is (2-4/2-1) and (2-5/2-1) which differs from *Cyrtolaelaps*, genu III is (2-4/2-2); *Euepicrius*, genu IV is (2-5/1-1); *Sessiluncus*, genu III (2-4/1-1) and genu IV is (2-5/1-1); *Gamasiphoides*, genu III is (2-4/1 or 2-1) and genu IV is (2-5/1-1); and *Gamasiphis*, genu III is (2-4/1-1) and genu IV is (2-5/1-0). On the palp genu, al_1 is short and spatulate with a lateral tine, while al_2 is longer and slightly spatulate near the tip.

On the palp femur, *al* is short and pilose near the tip. The dorsal setae of leg IV have been drawn for all species and it can be seen that on the tarsus, *md* is long and filamentous, while pd_2 is shorter, or if subequal, it has a tip which is blunt, spatulate or pilose. This is also true of a number of *Gamasellus* and *Gamaselliphis* with pilose dorsal setae. The smallness of pd_1 and pd_2 compared with ad_1 and ad_2 on femur IV, occurs in all but one *Ologamasus* species, and is found in a number of Rhodacarid genera. The ambulacral apparatus of leg I has smaller claws than those of the other legs and is without a pulvillus.

In the deutonymphs of the three species described there is a divided dorsal shield and the setal form is similar to that of the adults. The deutonymph of *Ologamasus cymosus*, unlike its own adult but like the adults of the other two groups of species, has twenty-two pairs of setae on the anterior dorsal shield. Only one protonymph has been described.

The new species of *Ologamasus* are dealt with in three groups. From Berlese's description of *Ologamasus aberrans*, it could belong to the *pyrenoides*-group or *cymosus*-group, but it should probably be placed in a group of its own. It should be noted, that in my re-definition of *Ologamasus*, I no longer exclude species in which the female ventrianal shield is not fused to the dorsal shield, as was done by Berlese (1888). This change may have to be revoked later, in which case the *discutatus*-group will be excluded from *Ologamasus*, to form a new genus, or to be placed in *Gamasellus*, which would in turn have to be re-defined to include species with an entire dorsal shield in the adult.

KEY TO *OLOGAMASUS* SPECIES FROM AUSTRALIA AND NEW ZEALAND

Females

1. Ventrianal shield fused to dorsal shield and sternal shield fused to endopodal shields IV. *cymosus*-group 2
   Ventrianal shield fused to dorsal shield and sternal shield not fused to endopodal shields IV. *pyrenoides*-group . . . . . *pyrenoides* sp. nov.
   Ventrianal shield not fused to dorsal shield and sternal shield not fused to endopodal shields IV. *discutatus*-group 6
2. Vertical setae simple 3
   Vertical setae pilose 5

3. Femur IV with 2 conical spurs . . . . . *cymosus* sp. nov.
   Femur IV without conical spurs 4

4. Dorsal setae in row *R* of normal length (subequal with *S*1) and on femur IV, pd_2 about $\frac{1}{4}$ the length of ad_2 . . . . . *mansoni* sp. nov.
   Dorsal setae in row *R* very small (subequal with *z*1) and on femur IV, pd_2 is longer than ad_2 . . . . . *leptosceles* sp. nov.

5. Femur III without conical spurs and dorsal setae in row *R* are pilose . . . . . *dumosus* sp. nov.
   Femur III with 1 conical spur and dorsal setae in row *R* are simple . . . . . *nucilis* sp. nov.

6. Vertical setae are simple . . . . . *litoprothrix* sp. nov.
   Vertical setae are pilose 7

7. No dorsal setae on leg IV are pilose 8
   Pilose dorsal setae on leg IV 9

8. Femur IV without a sickle-like spur . . . . *discutatus* sp. nov.
   Femur IV with sickle-like spur . . . . . *tindalei* sp. nov.

9. One pair of ventral setae are pilose and seta *v* on femur IV is simple . . . . . *southcotti* sp. nov.
   Three pairs of ventral setae are pilose and seta *v* on femur IV is a short spur . . . . *virgosus* sp. nov.

Males

1. Sternogenital shield not fused with ventrianal shield and peritrematal shield fused with ventrianal shield. *cymosus*-group . . 2
   Sternogenital shield fused with ventrianal shield and peritrematal shield fused with ventrianal shield. *pyrenoides-group* . . . . *pyrenoides* sp. nov.
   Sternogenital shield not fused to ventrianal shield and peritrematal shield not fused with ventrianal shield or, if partially fused, the ventrianal shield is not fused to the dorsal shield. *discutatus*-group 4

2. Vertical setae are pilose and tibia II is armed . . . . . *validus* sp. nov.
   Vertical setae are simple and tibia II is unarmed 3

3. Dorsal setae in row *R* are simple and there is a nodule on the posteriolateral surface of femur II . . . . . *mansoni* sp. nov.
   Dorsal setae in row *R* are pilose and there is no nodule on the posteriolateral surface of femur II . . . . . *cymosus* sp. nov.
4. Dorsal shield divided into two parts . . . . *discutatus* sp. nov.
   Dorsal shield entire 5
5. Ventrianal shield is fused to the dorsal shield . . . . . *tindalei* sp. nov.
   Ventrianal shield is not fused to dorsal shield . . . . . *southcotti* sp. nov.

CYMOSUS—GROUP

The six species belonging to this group are from North Island, New Zealand. The adults range in length of idiosoma from 350μ to 890μ.

Female. Gnathosoma. The anterior edge of the tectum curves forwards from the sides to a central, pointed process. The margin is denticulate, some of the teeth may be large, sometimes forming a pointed process each side of the central process. The chelicerae have three teeth on the movable digit and three or four teeth, sometimes with a series of small teeth distally, on the fixed digit. The rostral and internal posterior rostral setae are longer than the external posterior rostral and capitular setae. On the palp trochanter, *av* is pilose near the tip, while *pv* is simple.

Idiosoma. Obvious reticulation on the sclerotized shields occurs in the three species with pilose vertical setae. The dorsal shield is fused posteriorly with the ventrianal shield, a short lateral fissure separating it from the anterior of the ventrianal shield and the posterior of the peritrematal shield. The peritrematal shield is sometimes fused with the ventrianal shield, but when it is separate, it proceeds posteriorly well on to the opisthosoma, coming gradually to a point. There is a single pair of prae-endopodal shields. The sternal shield is fused with all the endopodal shields. There are fewer setae on the idiosoma in this group compared with the other two groups of species and the post-lateral setae and dorsal row of setae, *UR*, are not considered to exist. There are usually twenty-one pairs of setae on the podonotum, the anterior seta of row *r* in the two other groups being missing. The chaetotaxy of the opisthonotum is more variable, especially laterally, but there are always five setae in row *Z* and four setae in row *S*. In the three species with pilose

vertical setae there are five, instead of four, setae in row *J*. There are always both pilose and simple setae on the dorsal shield. The pilose setae sometimes have at their tip what may be the rudimentary equivalent of the diaphanous flap that occurs in the *discutatus*-group. The chaetotaxy of the venter is regular.

Legs. There is a conical spur on at least femur II, and sometimes on femur III and IV as well. Also a number of setae, especially on the proximal segments of leg IV, are large and thorn-like.

Male. The movable digit on the chelicerae has the same number of teeth as the female. The spermodactyl is only slightly longer than the movable digit and is fairly stout. The dorsal shield is always entire. The sternogenital shield is separate from the ventrianal shield. In *O. validus* there are eight ventral setae and not seven as there are in the other two males. Also it has tibia II armed as well as femur II and genu II. There are never any conical spurs on femur III and IV.

Ologamasus cymosus sp. nov.

Female. Fig. 3-5. Idiosomal length, 400μ.

The peritrematal shield is separate from the ventrianal shield. The vertical setae, and two other pairs of dorsal setae, are simple, the others being pilose. The central dorsal setae are blunt ended and only pilose distally. The lateral dorsal setae, including the whole of row *r* and *R*, are filamentous and pilose along most of their length. The first pair of sternal setae are blunt at the tip and the fourth pair are small. The anterior four pairs of ventral setae are smaller than the others and the posterior two pairs are pilose, as in row *R*. There is a conical spur on femur II and III, and two conical spurs on femur IV. On trochanter IV, *al* is thorn-like.

Male. Fig. 6 and 7. Idiosomal length, 350μ.

The spermodactyl is slightly sinuous, tapering gradually to a blunt point. The dorsal setae are similar to those of the female, but the lateral ones are less pilose, as is also true of the posterior two pairs of ventral setae. The first pair of sternogenital setae are less than half the length of the others. The femur and genu of leg II are armed.

Deutonymph. Fig. 8 and 9. Idiosomal length, 360μ.

There is obvious reticulation on the shields. The dorsal chaetotaxy is similar to the adults, but there is one more pair of setae on the anterior dorsal shield. The form of the central dorsal setae is like that of the adults, but the lateral ones are small and less pilose. As in the adult the posterior two pairs of ventrals are pilose and on trochanter IV, *al* is thorn-like.

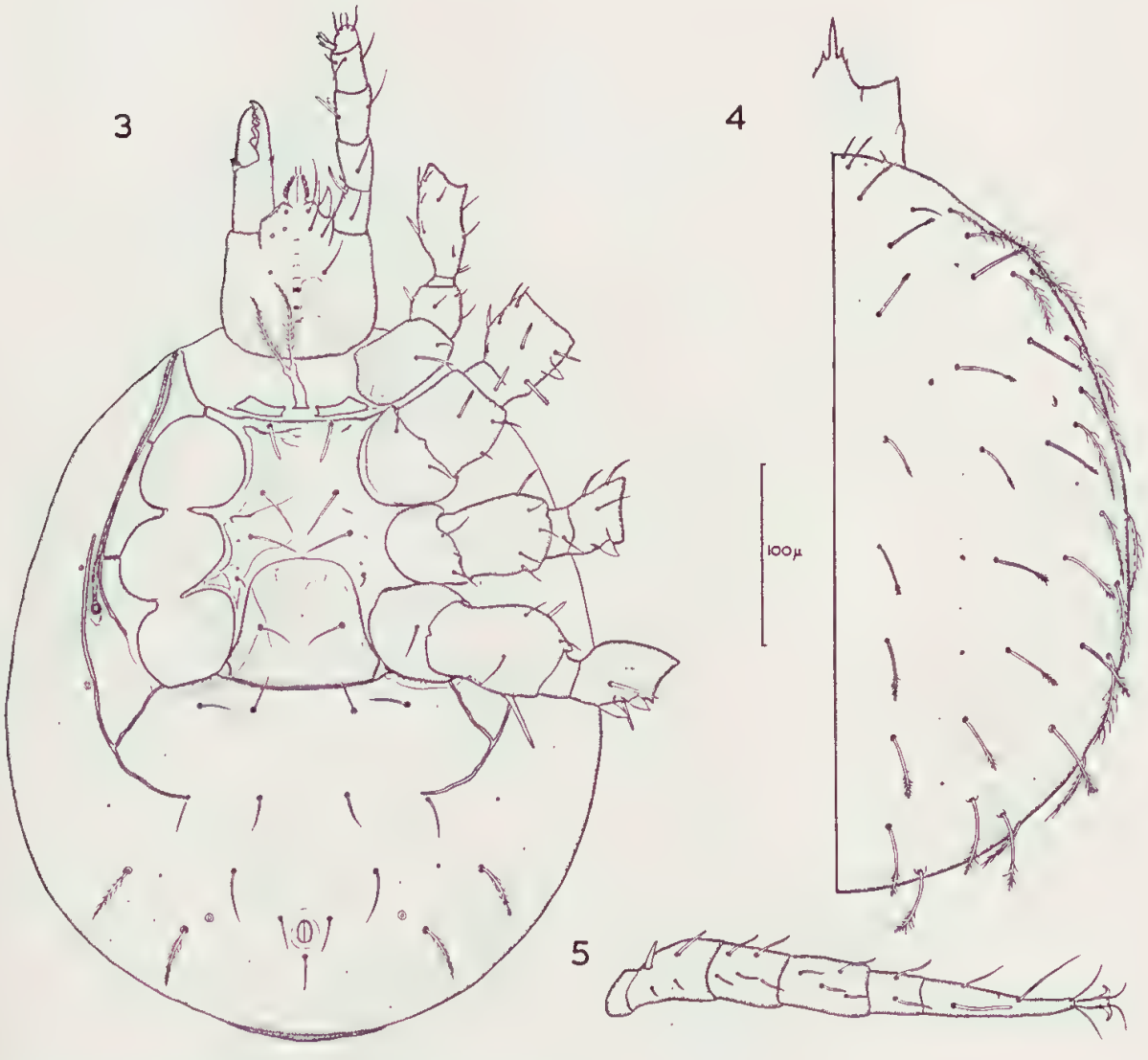


Fig. 3-5. *Ologamasus cymosus* sp. nov.
Fig. 3. Venter of female.
Fig. 4. Dorsum of female.
Fig. 5. Dorsum of distal segments from leg IV of female.

Locality: North Island, New Zealand; holotype female, allotype male, morphotype deutonymph, 6 paratype females, 8 paratype males and 2 paratype deutonymphs from leaf mould, Botanical Gardens, Wellington, December, 1960, coll. D. C. M. Manson.

Ologamasus mansoni sp. nov.

Female. Fig. 10-12. Idiosomal length, 470μ.

The peritrematal shield is separate from the ventrianal shield. The vertical setae are simple. There are more simple dorsal setae than on *O. cymosus*, which is most striking in row *R*. The sternal setae are as *O. cymosus*. All the ventral setae are simple. The lateral fissure is notched around a pore, about the level of the posterior

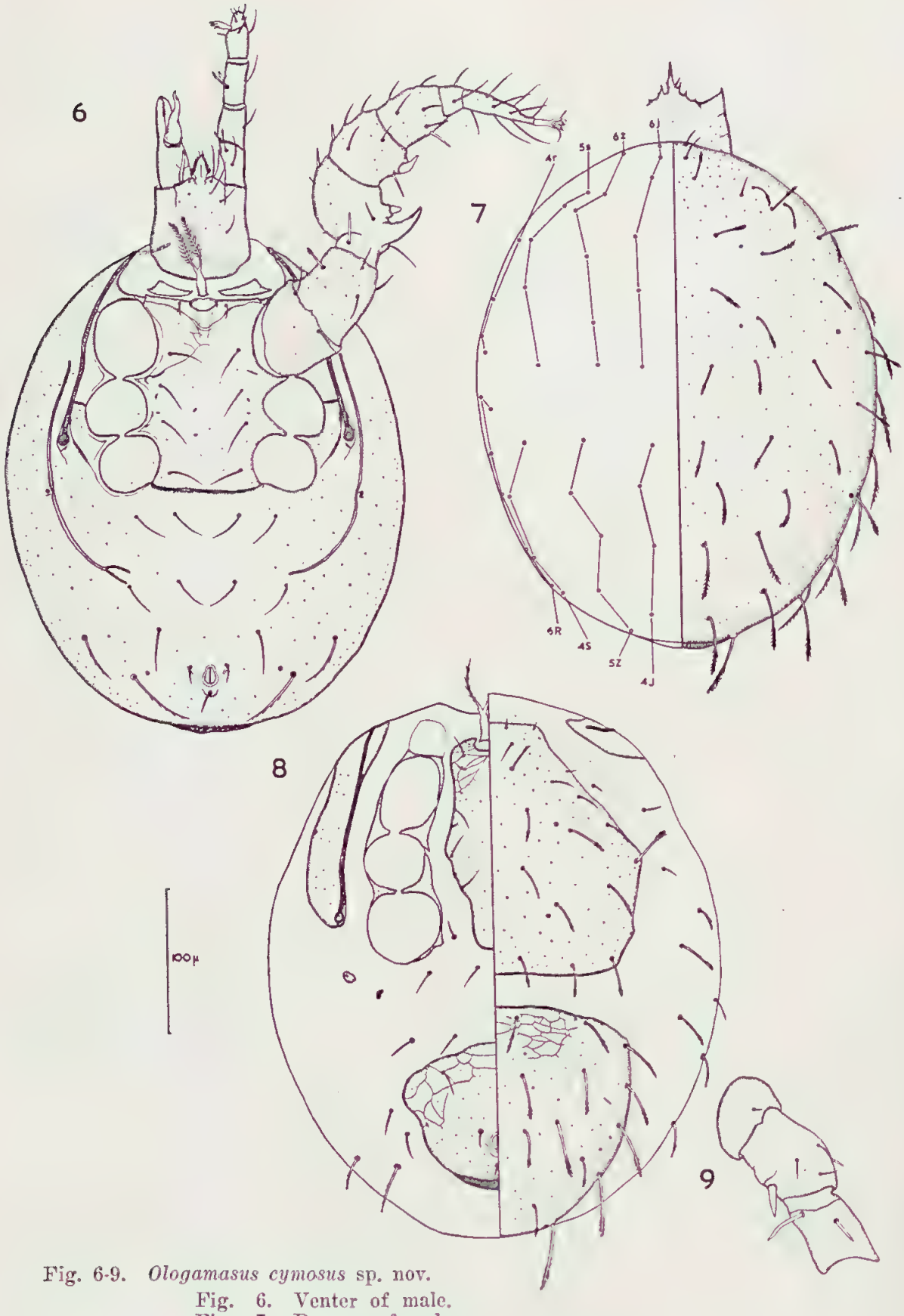


Fig. 6-9. *Ologamasus cymosus* sp. nov.

Fig. 6. Venter of male.
Fig. 7. Dorsum of male.
Fig. 8. Venter and dorsum of deutonymph.
Fig. 9. Venter of basal segments from leg IV of deutonymph.

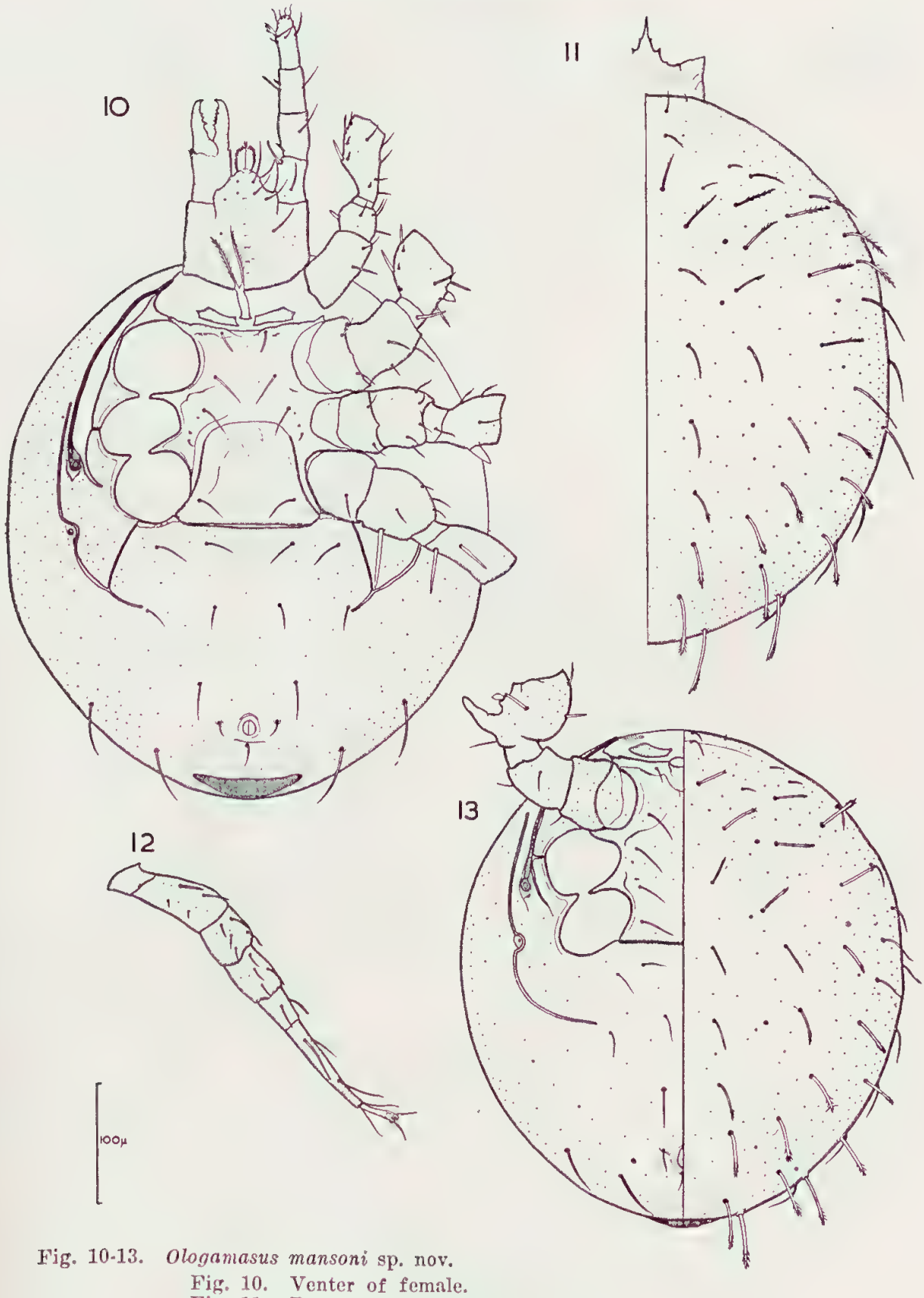


Fig. 10-13. *Ologamasus mansoni* sp. nov.

Fig. 10. Venter of female.
Fig. 11. Dorsum of female.
Fig. 12. Dorsum of distal segments from leg IV of female.
Fig. 13. Venter and dorsum of male (N.B. leg II shows posterolateral surface).

margin of the podosoma. There is a conical spur of femur II and III, but not on femur IV. On femur IV, ad_2 is not so robust as in *O. cymosus*. On trochanter IV, *al* is filamentous.

Male. Fig. 13. Idiosomal length, 410μ.

As in *O. cymosus* the dorsal setae are less pilose than in the female. Otherwise, as in the female, except for the male characters which are mainly as in *O. cymosus*. There is a nodule on the posterio-lateral surface of femur II which is not present in *O. cymosus*.

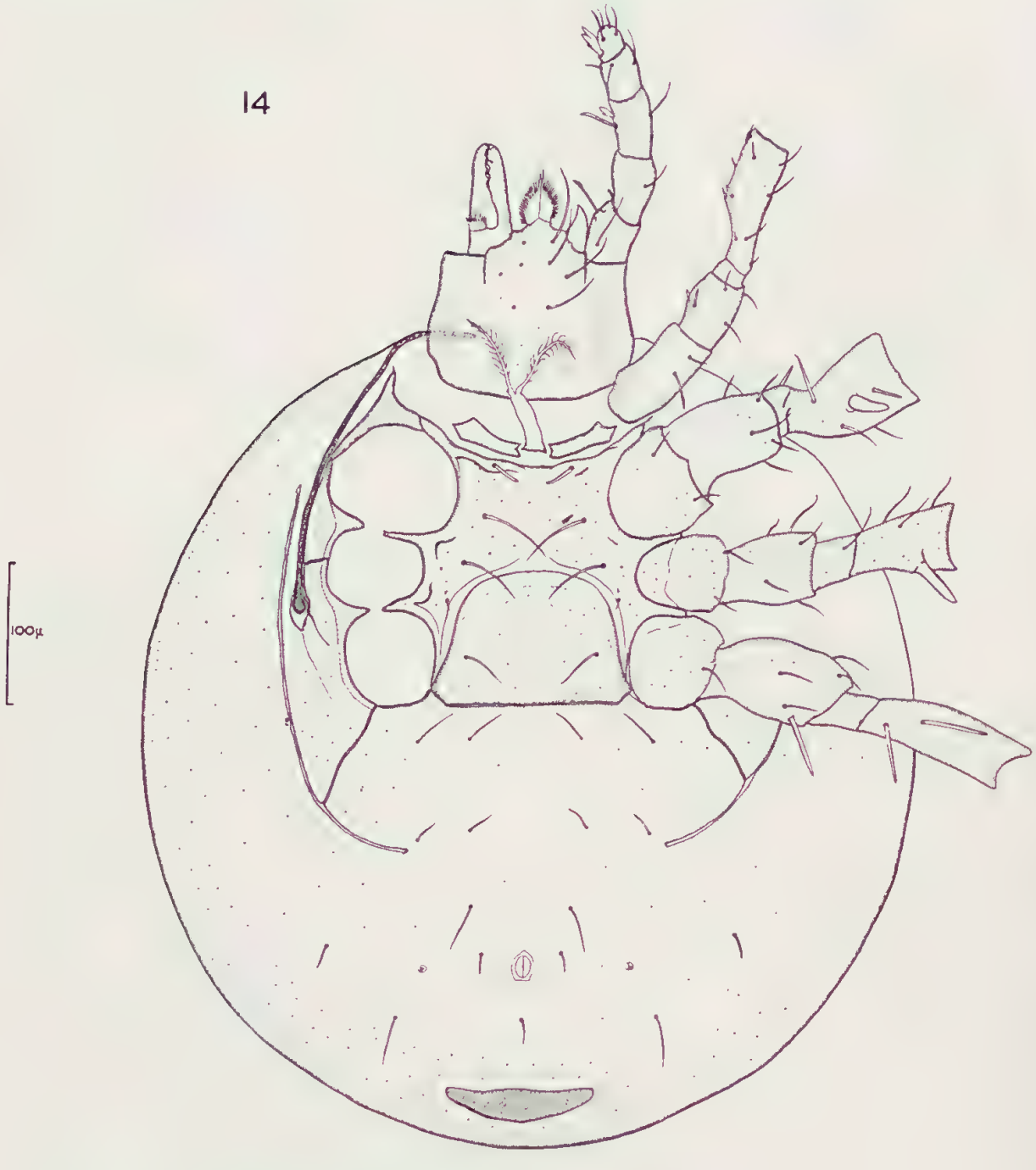


Fig. 14. *Ologamasus leptosceles* sp. nov.
Fig. 14. Venter of female.

Locality: North Island, New Zealand; holotype female, allotype male, 2 paratype females and 1 paratype male from leaf mould, Botanical Gardens, Wellington, December, 1960, coll. D. C. M. Manson.

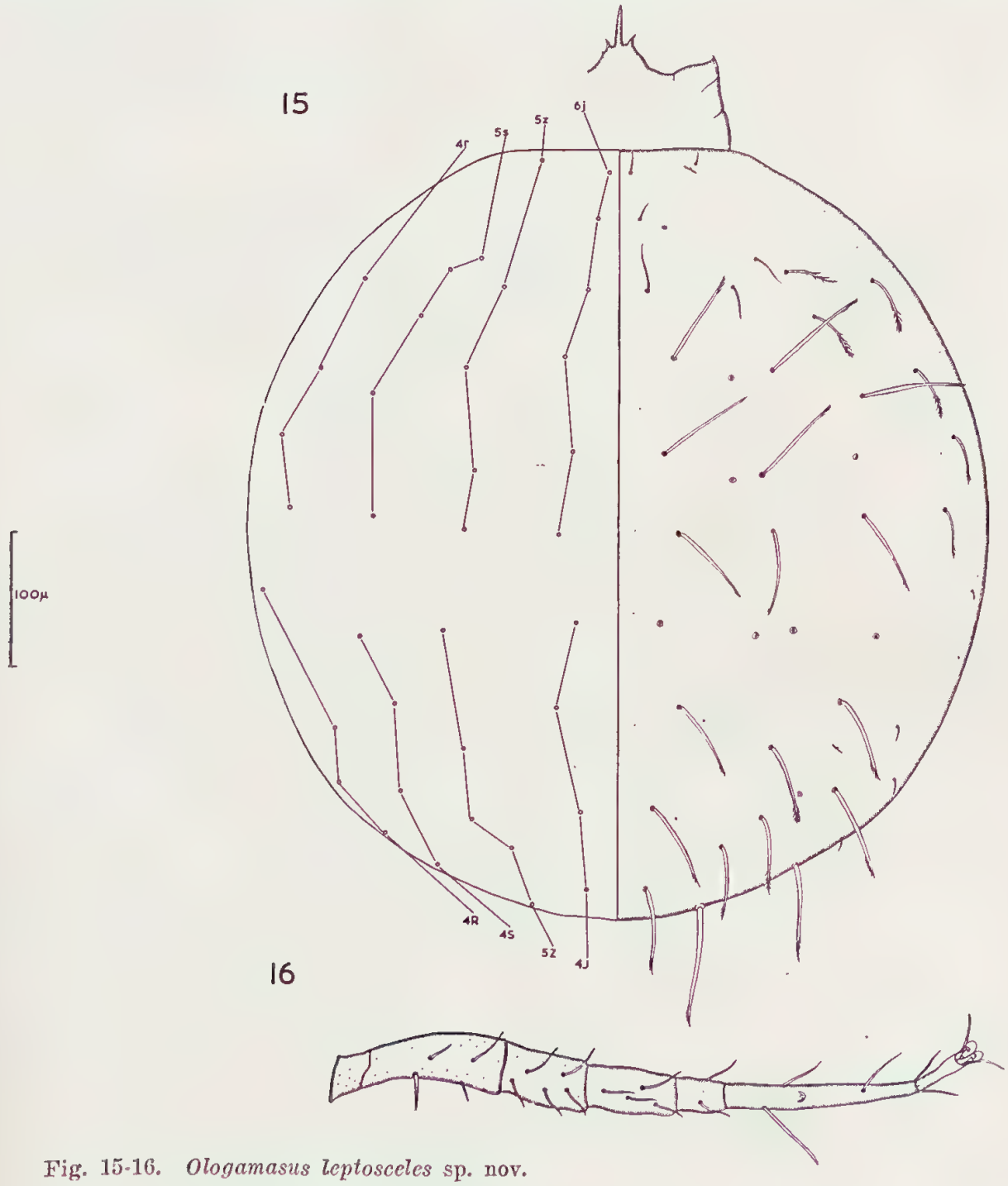


Fig. 15-16. *Ologamasus leptosceles* sp. nov.
Fig. 15. Dorsum of female.
Fig. 16. Dorsum of distal segments from leg IV of female.

Ologamasus leptosceles sp. nov.

Female. Fig. 14-16. Idiosomal length, 570μ.
The peritrematal shield is separated from the ventrianal shield.

The vertical setae are simple. There is a reduction in the number of dorsal setae, there being only five setae in row *Z* and four setae in row *R*. The setae in row R are very small and subequal in length to *z*1. The sternal are as in *O. cymosus*. The anterior of the posterior

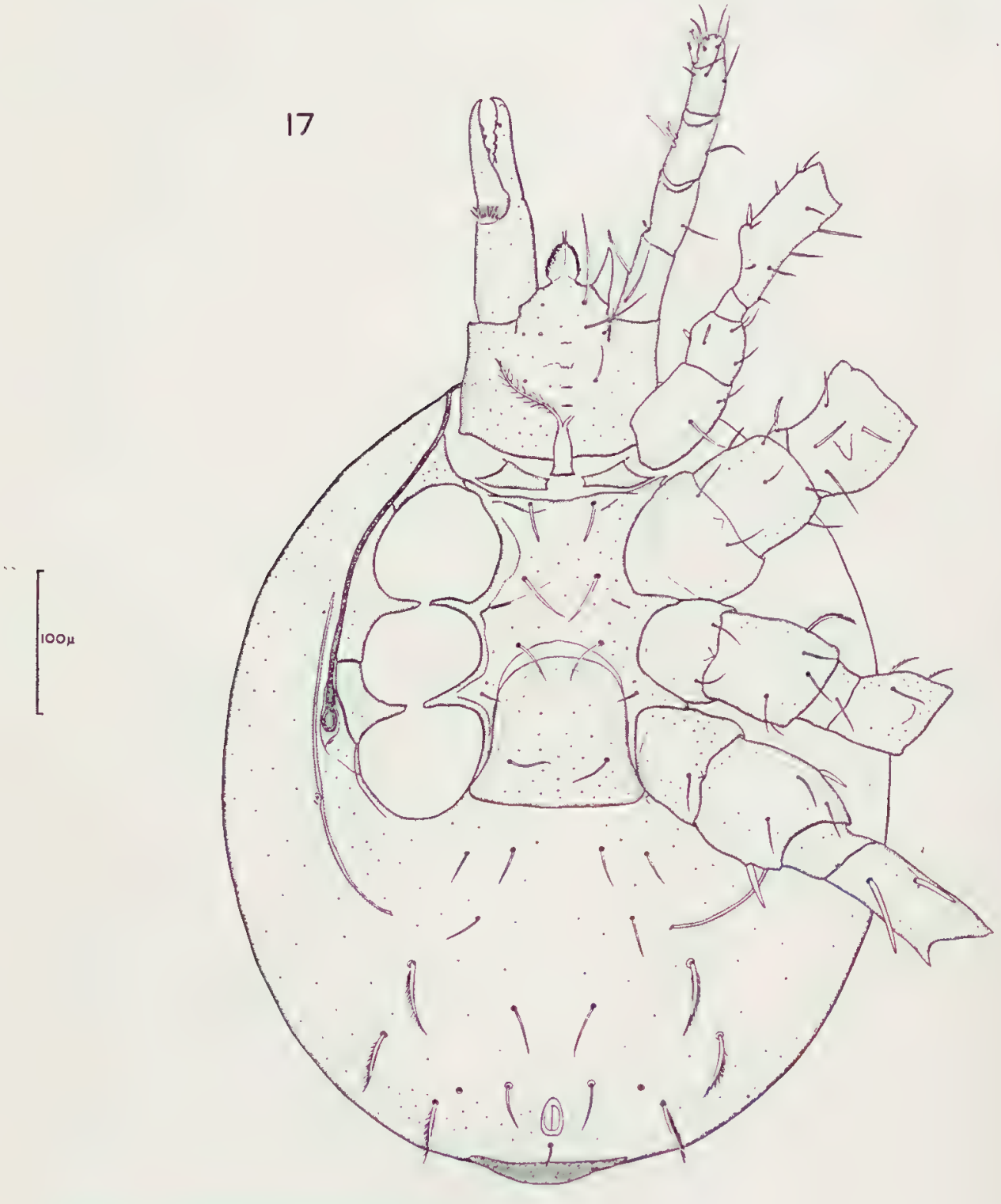


Fig. 17. *Ologamasus dumosus* sp. nov.
Fig. 17. Venter of female.

two pairs of ventral setae is only half the length of the other and not subequal. There is a conical spur on femur II and III only. On trochanter IV, *al* is filamentous. The dorsal setae of femur IV are unusual in pd_2 being larger than ad_2.

Locality: North Island, New Zealand; holotype female from leaf mould, Khandallah, Wellington, 19 December, 1961, coll. D. C. M. Manson.

Ologamasus dumosus sp. nov.

Female. Fig. 17-19. Idiosomal length, 560μ.

There is obvious reticulation on the shields. The peritrematal shield is fused to the ventrianal shield. The vertical setae are pilose. There are two more pairs of opisthonotal setae, one in row *J* and

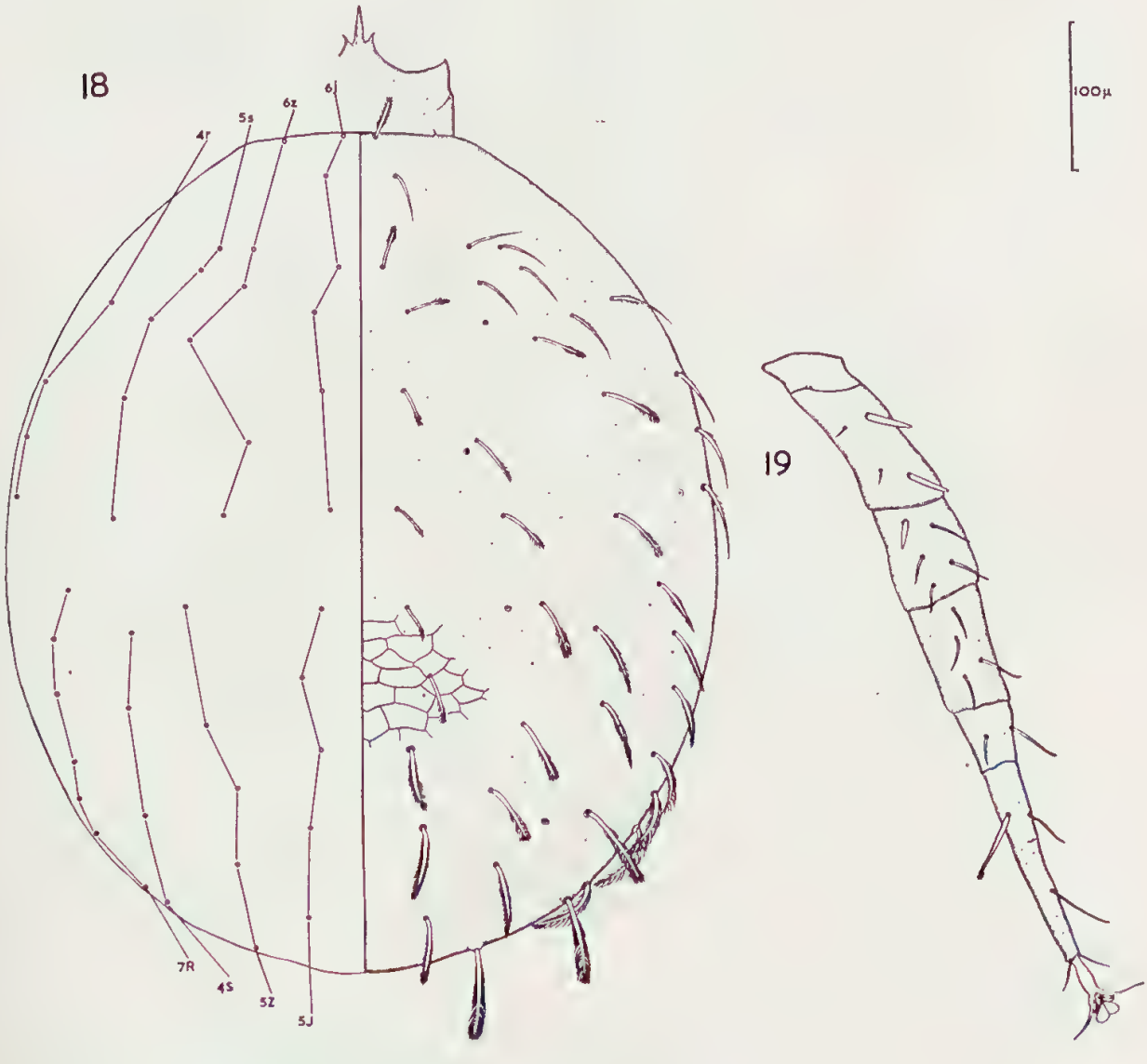


Fig. 18-19. *Ologamasus dumosus* sp. nov.
Fig. 18. Dorsum of female.
Fig. 19. Dorsum of distal segments from leg IV of female.

one in row *R*, than in *O. cymosus*. The opisthonotal setae are strongly pilose. The sternal setae are as *O. cymosus*. Three pairs of ventral setae are pilose. There is a conical spur on femur II only. Dorsally, on leg IV, ad_1 and ad_2 on the femur are equally thorn-like, and on the genu, pd_3 is thorn-like, also pd_2 on the tarsus is pilose at the tip. On trochanter IV, *al* is thorn-like.

Locality: North Island, New Zealand; holotype female from leaf mould, Botanical Gardens, Wellington, December 1960, coll. D. C. M. Manson.

Ologamasus nucilis sp. nov.

Female. Fig. 20-22. Idiosomal length, 800μ.

There is obvious reticulation on the shields. The peritrematal shield is partially fused to the ventrianal shield. The vertical setae are pilose. As in *O. dumosus*, there are five setae in row *J*. The setae in row *R* are simple. The first pair of sternal setae are only slightly longer than the fourth pair. All the ventral setae are simple.

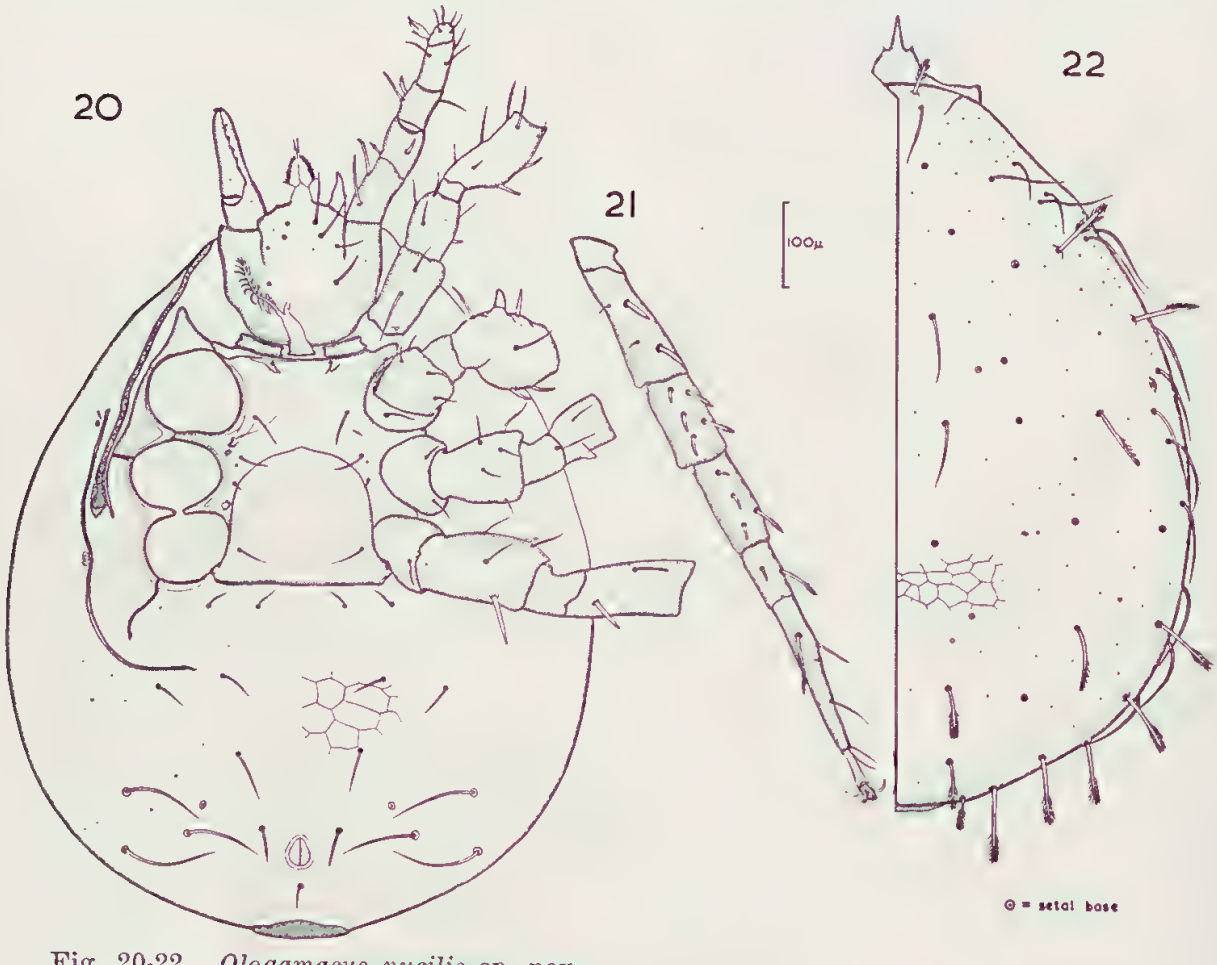


Fig. 20-22. *Ologamasus nucilis* sp. nov.
Fig. 20. Venter of female.
Fig. 21. Dorsum of distal segments from leg IV of female.
Fig. 22. Dorsum of female.

There are conical spurs on femur II and III only. A number of dorsal setae on leg IV, including pd_3 on the tarsus, are slightly pilose near the tip. On trochanter IV, *al* is thorn-like.

Fig. 23-25. *Ologamasus validus* sp. nov.
Fig. 23. Venter of male.
Fig. 24. Dorsum of distal segments from leg IV of male.
Fig. 25. Dorsum of male.

Locality: North Island, New Zealand; holotype female from leaf mould, Botanical Gardens, Wellington, December, 1960, coll. D. C. M. Manson.

Ologamasus validus sp. nov.

Male. Fig. 23-25. Idiosomal length, 890μ.

The spermodactyl is robust, with straight, parallel sides coming to a point suddenly. There is obvious reticulation of the shields. The vertical setae are pilose. As in *O. dumosus,* there are five setae in row *J*. The setae in row *R* are simple. The venter is similar to the male of *O. cymosus,* the posterior two pairs of ventral setae, for instance, are pilose. But it is unusual in having an extra, eighth pair of ventral setae. The tibia, as well as the femur and genu, of leg II is armed. On femur IV, *al* is unusual in being filamentous, while *v* and ad_2 form unusually stout thorns. A number of dorsal setae on leg IV, including pd_3 on the tarsus, are pilose. On trochanter IV, *al* is thorn-like.

Locality: North Island, New Zealand; holotype and paratype male from Waimamaku (about 100 miles north of Auckland), 21 October, 1938, coll. E. D. Pritchard.

PYRENOIDES—GROUP

There is only one species belonging to this group and that is from Victoria, Australia. The characters of the group are therefore limited to those of the species.

Ologamasus pyrenoides sp. nov.

Female. Fig. 26-28. Idiosomal length, 730μ.

Gnathosoma. The anterior edge of the tectum hardly curves forward at all from the sides and a robust, sword-like process projects from its centre. The margin is denticulate with a pair of small spines on the central process. The chelicerae have four large teeth on the movable digit and a single, large proximal tooth on the fixed digit, but much of the apposed edges of the two digits have a series of small uniform teeth. On the palp trochanter, *av* is obviously pilose and *pv* is thorn-like, as is *v* on the palp femur.

Idiosoma. There are two anterior protruberances bearing the vertical setae and a humeral protruberance on either side, which give the body a characteristic shape. There is obvious reticulation on the shields. The dorsal shield is fused posteriorly with the ventrianal shield, a short lateral fissure separating it from the anterior of the ventrianal shield, and the posterior of the peritrematal shield. The peritrematal shield is separate from the ventrianal shield and is truncated behind, at the level of the posterior margin of podosoma.

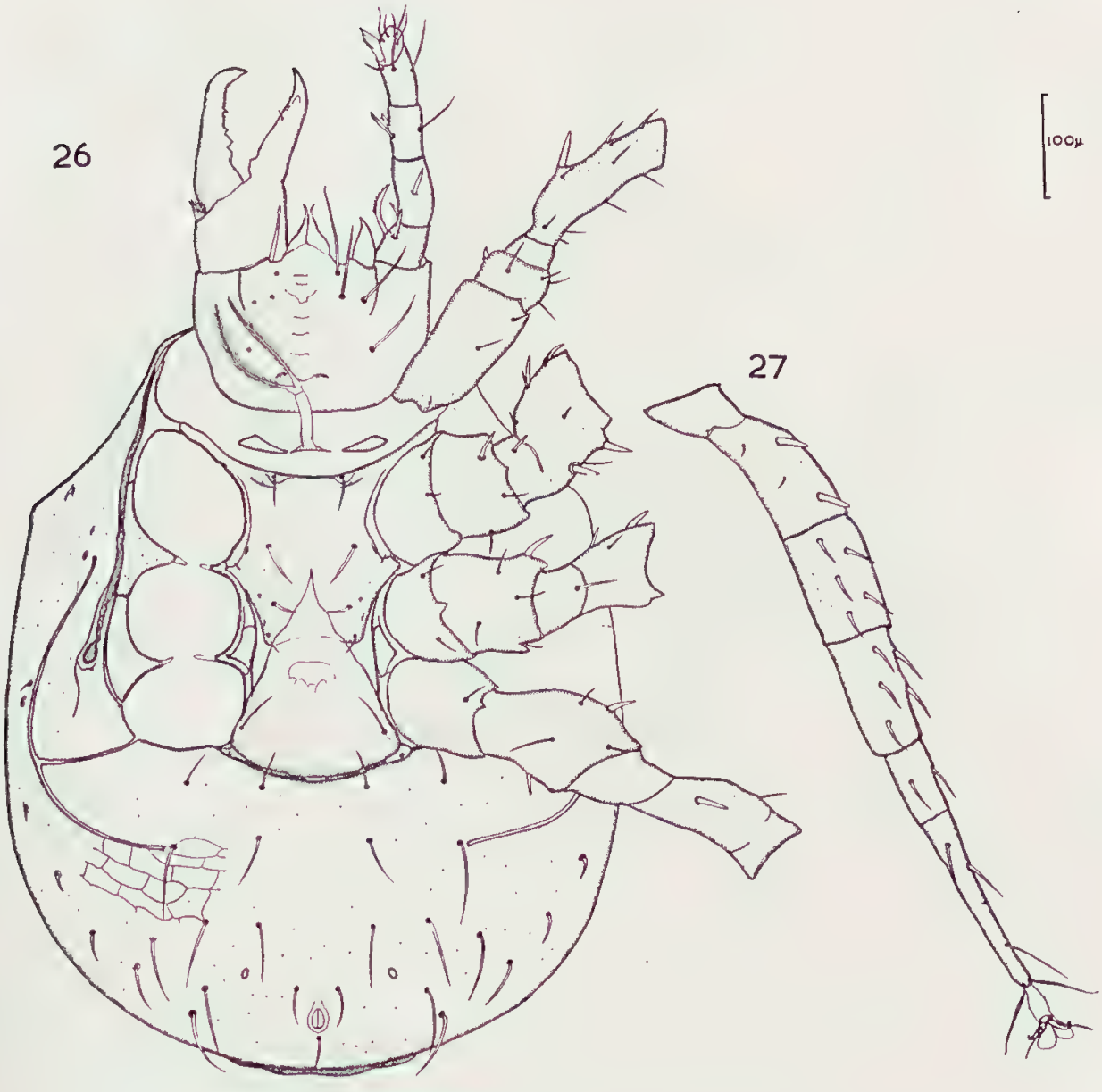


Fig. 26-27. *Ologamasus pyrenoides* sp. nov.
Fig. 26. Venter of female.
Fig. 27. Dorsum of distal segments from leg IV of female.

There is a single pair of prae-endopodal shields. The sternal shield is only fused with the endopodal shields II. Anteriorly, the genital shield comes to a point, which overlaps the sternal shield, reaching as far forward as the anterior edge of coxae III. There are twenty-two pairs of setae on the pronotum and twenty-three pairs on the opisthonotum. The vertical setae are large and spatulate. Three pairs of setae, *j*4, *z*5 and *r*2, are obviously pilose, but some of the posterior setae are slightly pilose. The second and third pairs of sternal setae are more robust. The dorsal setae row, *UR*, is considered to have only one pair. There are five pairs of post-lateral setae, which are smaller, the further anterior they are.

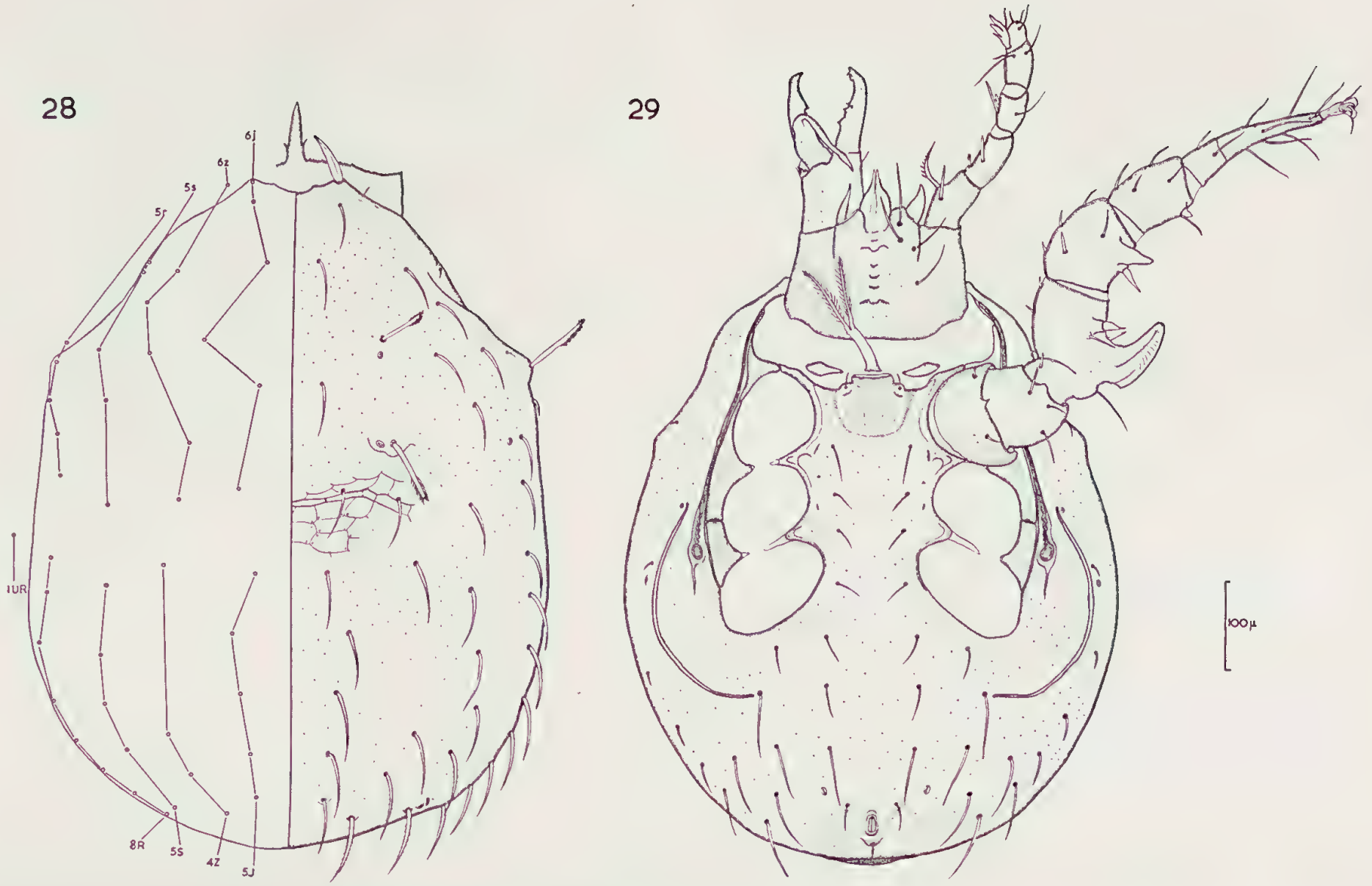


Fig. 28-29. *Ologamasus pyrenoides* sp. nov.
Fig. 28. Dorsum of female.
Fig. 29. Venter of male.

Legs. There are a number of thorn-like setae on the legs as in the *cymosus*-group, but there are no conical spurs. The last three pairs of legs have ad_1 and pd_1 on the tarsus longer than *md* and with a slight, diaphanous flap.

Male. Fig. 29. Idiosomal length, 640μ.

Gnathosoma. The movable digit on the chelicerae has a single tooth and the rest of the edge is smooth. The spermodactyl is bent over near its base so that it points backwards. The corniculi are slightly stalked.

Idiosoma. The dorsal shield is entire. The peritrematal shield is fused to the ventrianal shield. The sternogenital shield is fused to the ventrianal shield. The first pair of sternogenital setae are less than half the length of the others, none of which are spine-like.

Legs. Leg II has the femur, genu and tibia armed.

Locality: Victoria, Australia; holotype female, allotype male, 12 paratype females and 20 paratype males from "Antarctic Beech" (*Nothofagus cunninghamii*) litter, Beachamps Falls, Otway Ranges, 19 January, 1962, coll. G. F. Gross and P. F. Aitken.

DISCUTATUS—GROUP

The five species belonging to this group are from localities near the south-eastern coastline of Australia. The adults range in length of idiosoma from 550μ to 1,000μ.

Female. Gnathosoma. The anterior edge of the tectum curves forwards from the sides to a central pointed process. The margin is denticulate, some of the teeth may be large, sometimes forming a pointed process each side of the central process. The chelicerae have larger teeth, proximally and small teeth, distally, and the movable digit is less denticulate. On the palp trochanter both *av* and *pv* are simple.

Idiosoma. Obvious reticulation on the dorsal shields occurs on all species, except *O. litoprothrix,* which has simple vertical setae. The dorsal shield is separate from the ventrianal shield. The peritrematal shield is either separate from the ventrianal shield or it is partially fused to it. If it is separate, it is truncated behind at the level of the posterior margin of the podosoma. There are two or three pairs of prae-endopodal shields. The sternal shield is fused to the endopodal shields II and III. There are twenty-two pairs of setae on the podonotum. The setae *r*3, are off the dorsal shield. In three species there are thirty-three setae on the opisthonotum, but in the other two species this number is less. There are both pilose and simple setae on the dorsal shield. The pilose setae sometimes have a diaphanous

flap at the tip, as is found in some *Gamasellus* species and in *O. aberrans*. Also the simple setae, especially on the periphery, have a diaphanous, ventral ridge. The chaetotaxy of the venter is regular except that the post-lateral group of setae sometimes contains eight and sometimes seven pairs. Sometimes, one or more of the posterior pairs of ventral setae are pilose.

Legs. There are no thorn-like setae on the legs as there are in the previous two groups, and no conical spurs as there are in females of the *cymosus*-group.

Male. Gnathosoma. The movable digit on the chelicerae has a single tooth and the rest of the edge is smooth. The spermodactyl is longer than the movable digit, and quite slender, tending to be sinuous and swollen slightly at the tip.

Idiosoma. The dorsal shield is entire in all but one species, *O. discutatus*, where it is divided. In two out of the three described males, the dorsal shield is fused to the ventrianal shield, in which case the peritrematal shield is separate from the ventrianal shield, but where the ventrianal shield is separate from the dorsal shield it is partially fused to the peritrematal shield. The dorsal chaetotaxy is as in the female, but in *O. tindalei*, *r*3 is on the peritrematal shield. The sternogenital shield is separate from the ventrianal shield.

Legs. Leg II has the femur, genu and tibia armed.

Ologamasus discutatus sp. nov.

Female. Fig. 30-32. Idiosomal length, 820μ.

The vertical setae are pilose. Thirty-three pairs of opisthonotal setae. Besides *j*1, the following setae are pilose; *j*4, *z*5, *r*2, *J*3, *J*4, *J*6, *Z*3, *Z*6, *S*1 and *S*6. The posterior pair of ventral setae are pilose. All eight post-lateral setae are on the interscutal membrane.

Male. Fig. 33 and 34. Idiosomal length 740μ.

This male is unusual in being the only adult in the genus with a divided dorsal shield. The ventrianal shield is fused to the dorsal shield. Except for the above points and the sexual characters which are as for the group, the male is like the female.

Deutonymph. Fig. 35. Idiosomal length, 530μ.

The setal form and chaetotaxy is similar to the adult, but in row *J* and *Z* there appears to be a pair of setae missing, and in row *J* none of the setae are pilose.

Protonymph. Fig. 36. Idiosomal length, 450μ.

The number of setae is considerably reduced.

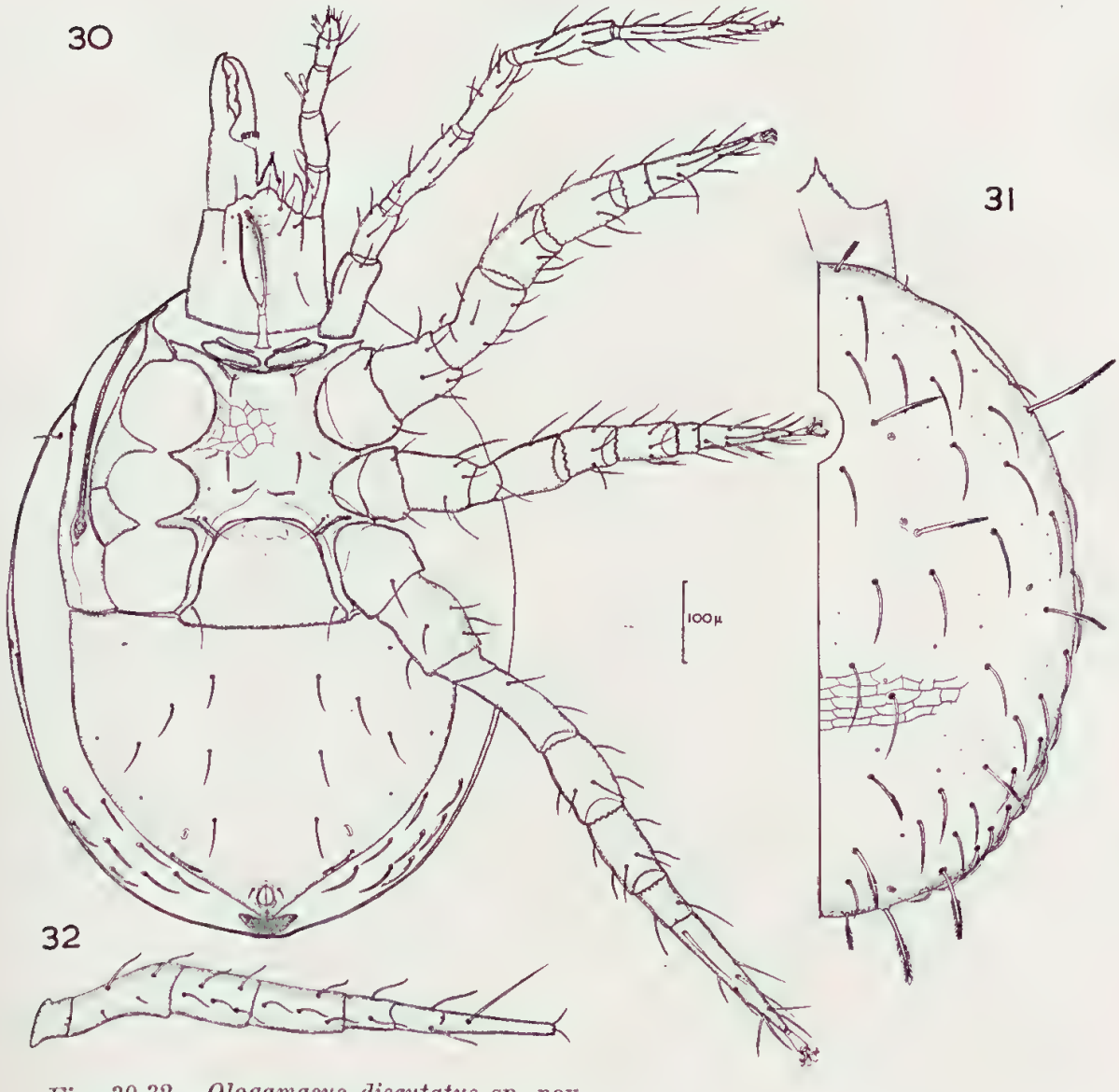


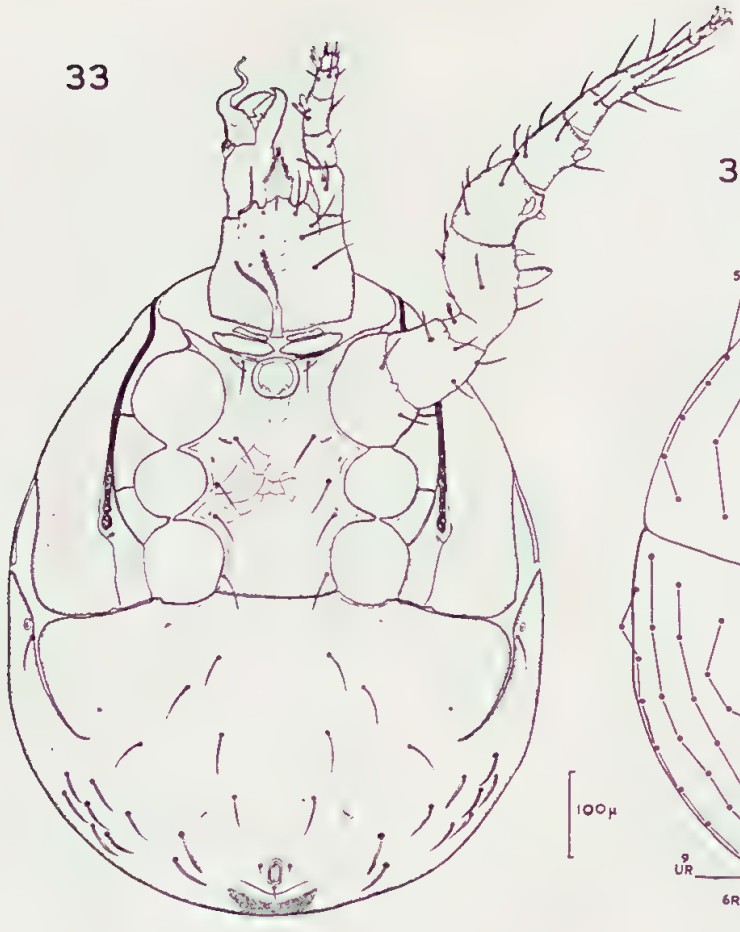
Fig. 30-32. *Ologamasus discutatus* sp. nov.
Fig. 30. Venter of female.
Fig. 31. Dorsum of female.
Fig. 32. Dorsum of distal segments from leg IV of female.

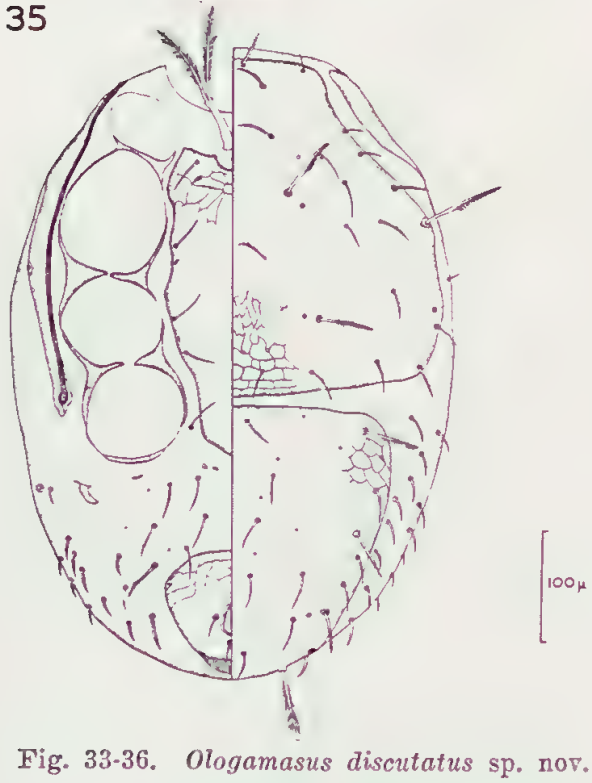
Locality: Victoria, Australia; holotype female, allotype male, morphotype deutonymph, morphotype protonymph, 2 paratype females, 9 paratype males, 13 paratype deutonymphs and 2 paratype protonymphs from leaf litter, 2-6 miles north of Sardine Creek (just south of the Australian Alps), 23 November, 1959, coll. G. F. Gross.

Ologamasus litoprothrix sp. nov.

Female. Fig. 37-39. Idiosomal length, 750μ.

Vertical setae are simple. Thirty-three pairs of opisthonotal setae. There are four pilose pairs of dorsal setae; *j*4, *z*5, *r*2, and *Z*6. None of the ventral setae are pilose. Three pairs of the post-lateral





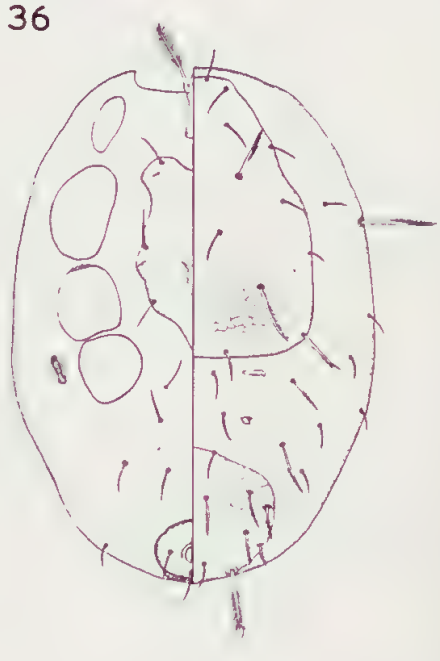


Fig. 33-36. *Ologamasus discutatus* sp. nov.

Fig. 33. Venter of male.
Fig. 34. Dorsum of male.
Fig. 35. Venter and dorsum of deutonymph.
Fig. 36. Venter and dorsum of protonymph.

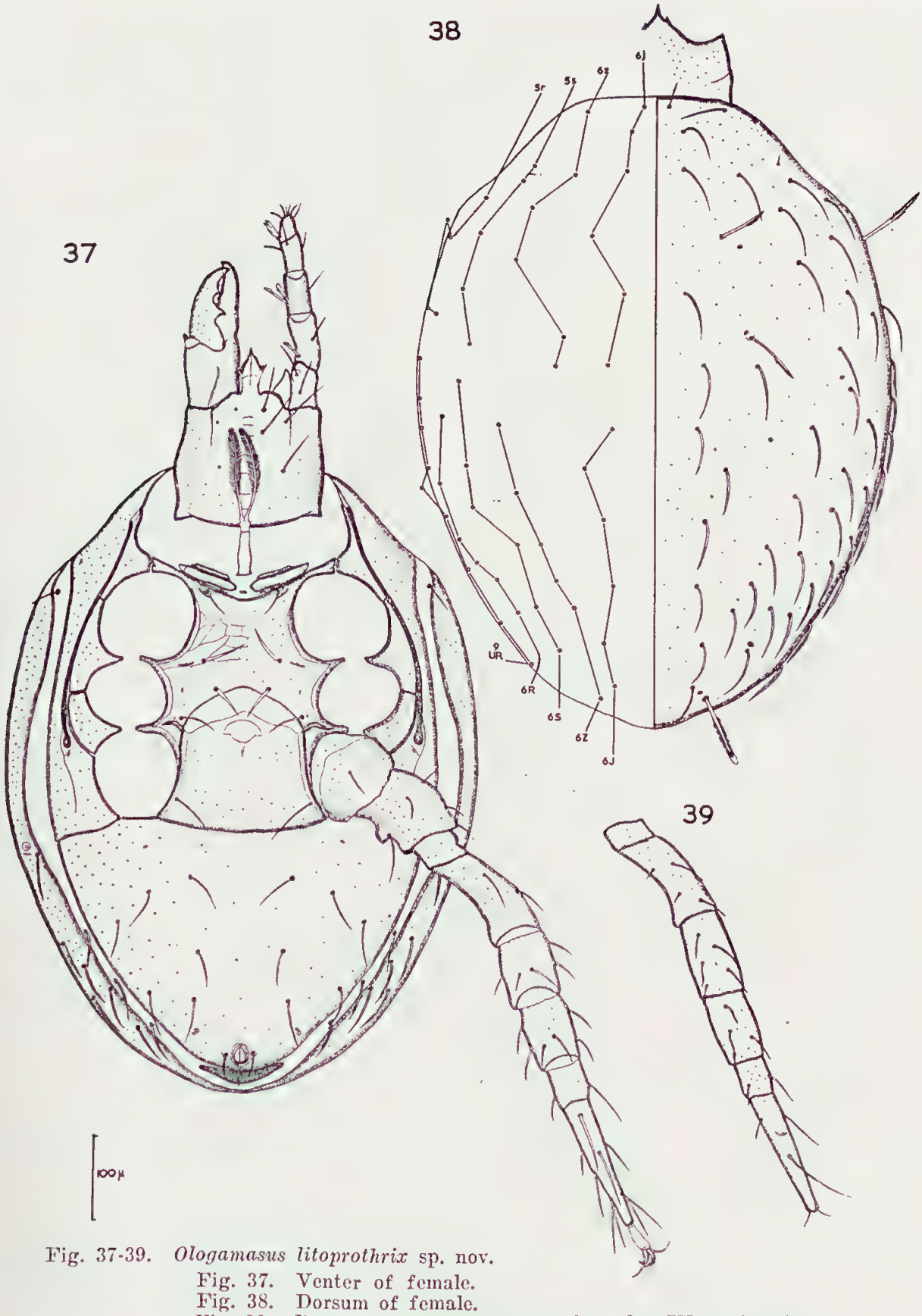


Fig. 37-39. *Ologamasus litoprothrix* sp. nov.
Fig. 37. Venter of female.
Fig. 38. Dorsum of female.
Fig. 39. Dorsum of distal segments from leg IV of female.

are on the interscutal membrane and five pairs on the dorsal shield. Trochanter IV has a small spur on its postero-lateral surface.

Locality: Victoria, Australia; holotype female, and 2 paratype females from leaf litter and moss, Turtons Track, Otway Ranges, 18 January, 1962, coll. G. F. Gross and P. F. Aitken.

Ologamasus tindalei sp. nov.

Female. Fig. 40 and 41. Idiosomal length, 1,000μ.

This species is very like *O. discutatus.* There are two obvious differences: only four pairs of post-lateral setae are on the interscutal

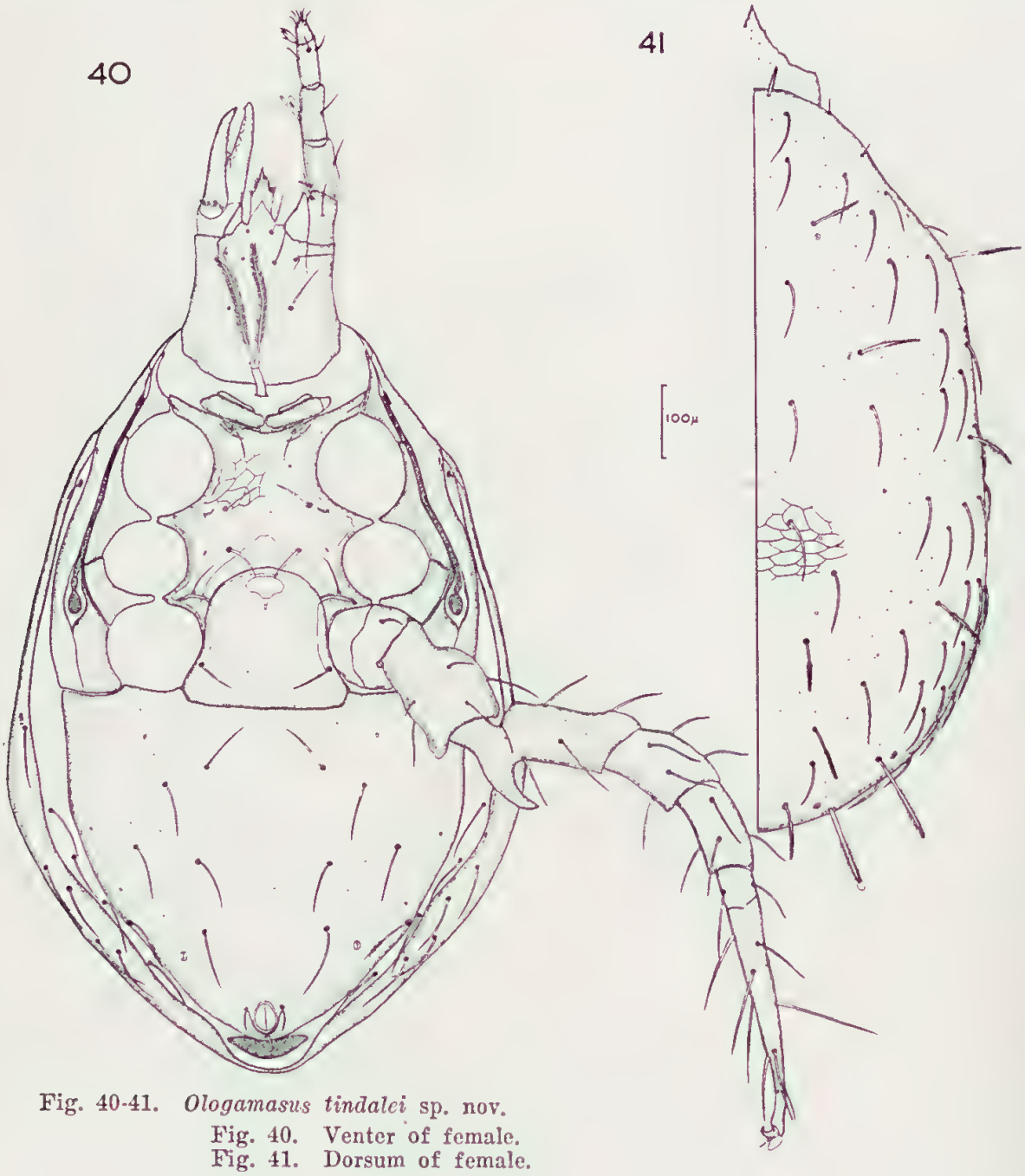


Fig. 40-41. *Ologamasus tindalei* sp. nov.
Fig. 40. Venter of female.
Fig. 41. Dorsum of female.

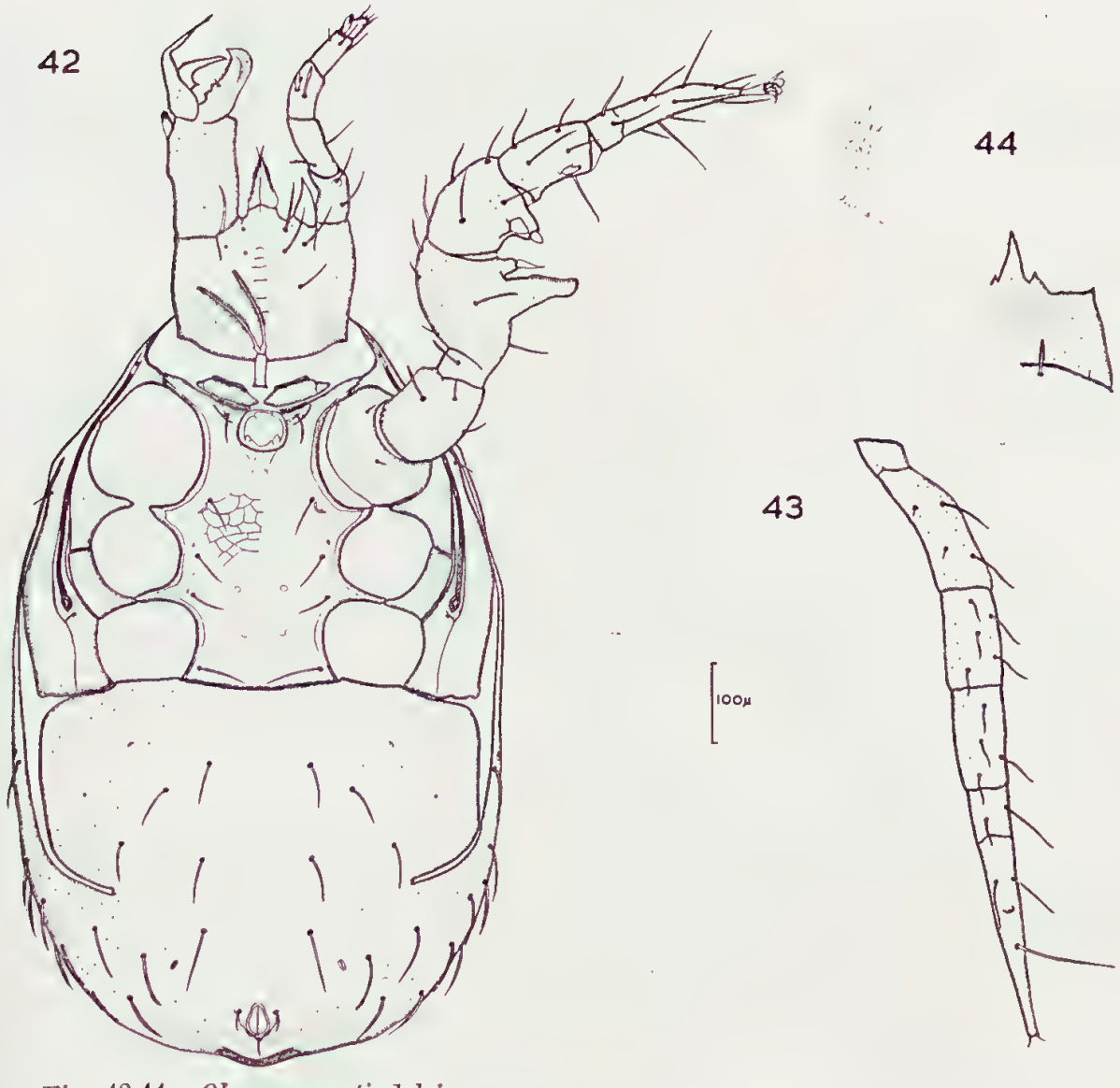


Fig. 42-44. *Ologamasus tindalei* sp. nov.
Fig. 42. Venter of male.
Fig. 43. Dorsum of distal segments from leg IV of male.
Fig. 44. Tectum of male.

membrane, the other four are on the dorsal shield; femur IV has a sickle-like spur on its posterolateral surface.

Male. Fig. 42-44. Idiosomal length, 930μ.

Differs from *O. discutatus* in having an entire dorsal shield. Also the spermodactyl is somewhat angular and the fixed digit has a dorsal crest. The posterior spur on genu II is raised on a process.

Locality: Australian Capital Territory, Australia; holotype female (LF3M1) and allotype male (LF3M2) from moss and litter among "Snow Grass" near "Snow Gums" (*Eucalyptus niphophila*) at 5,700 feet on Mount Ginini (northern edge of Australian Alps), 17 October, 1965, coll. N. B. Tindale.

Ologamasus southcotti sp. nov.

Female. Fig. 45-46. Idiosomal length, 730μ.

The dorsum is similar to *O. discutatus,* but there are only twenty-nine pairs of setae on the opisthonotum, the reduction in number being

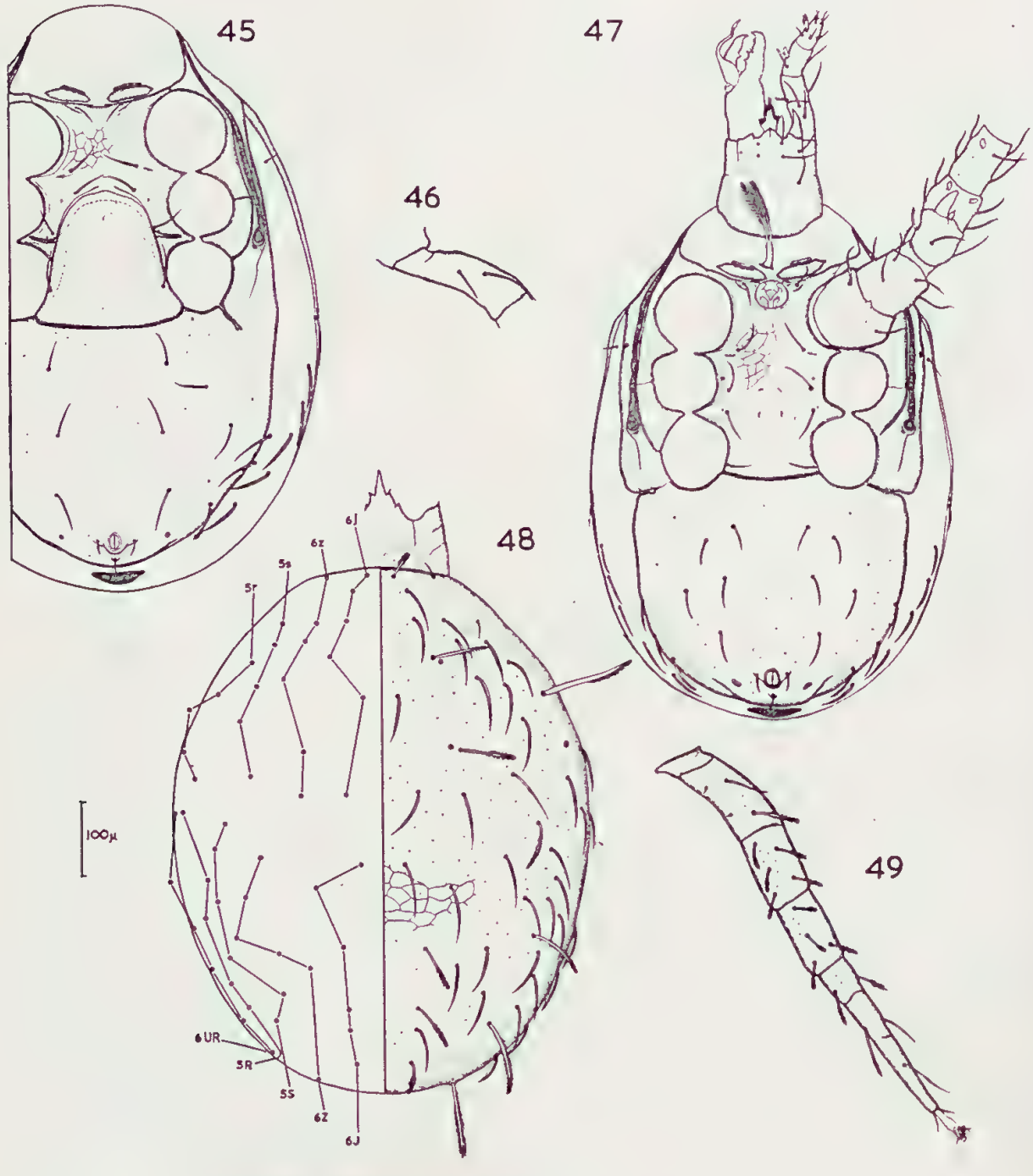


Fig. 45-49. *Ologamasus southcotti* sp. nov.

Fig. 45. Venter of female.
Fig. 46. Venter of femur IV of female.
Fig. 47. Venter of male.
Fig. 48. Dorsum of male.
Fig. 49. Dorsum of distal segments from leg IV of male.

in the peripheral rows, *R* and *UR*. There are two pairs of prae-endopodal shields, the small posterior pair appears to be fused with the sternal shield. The peritrematal shield is partially fused to the ventrianal shield. The posterior pair of ventral setae are pilose. There appears to be only seven pairs of post-lateral setae, all on the interscutal membrane. Seta *v* on femur IV is simple. A number of dorsal setae on leg IV are pilose.

Male. Fig. 47-49. Idiosomal length, 690μ.

The spermodactyl and spurs on leg II are similar to those of *O. discutatus*. It is the only known male in the genus with the ventrianal shield separate from the dorsal shield. There are three pairs of prae-endopodal shields. The setae are as in the female, but one post-lateral pair is on the ventrianal shield.

Locality: New South Wales, Australia; holotype female (LF72M1) and allotype male (LF72M2) from *Eucalyptus* leaf litter and grass, Gogerley Point (about 20 miles south of Sydney), 7 August, 1965, coll. R. V. Southcott.

Ologamasus virgosus sp. nov.

Female. Fig. 50-52, and 54. Idiosomal length, 550μ.

Besides *z*1 being pilose, the pilose dorsal setae are as in *O. discutatus*, but because there are only twenty-three pairs of setae on the opisthonotum their numbers are different (*i.e.*, *J*3, *J*4, *J*6, *Z*2, *Z*4, *S*1 and *S*2) in this region. The peritrematal shield is partially fused to the ventrianal shield. Three pairs of ventral setae are pilose. One pair of post-lateral setae is on the ventrianal shield. Seta *v* on femur IV is modified to a short spur. More setae on leg IV are pilose than in *O. southcotti* and there are pilose dorsal setae on legs II and III.

Deutonymph. Fig. 53. Idiosomal length, 460μ.

A lot of dorsal setae are pilose, but the setal pair, *Z*1, are not. There are twenty-four pairs of setae on the opisthonotum, there being an extra pair between what would be *Z*3 and *Z*4 in the female. The form of the leg setae is as in the female, except that *v* on the femur is not so stout.

Locality: New South Wales, Australia; holotype female (LF72M3), morphotype deutonymph (LF72M4) and paratype deutonymph (LF72M5) from *Eucalyptus* leaf litter and grass, Gogerley Point (about 20 miles south of Sydney), 7 August, 1965, coll. R. V. Southcott.

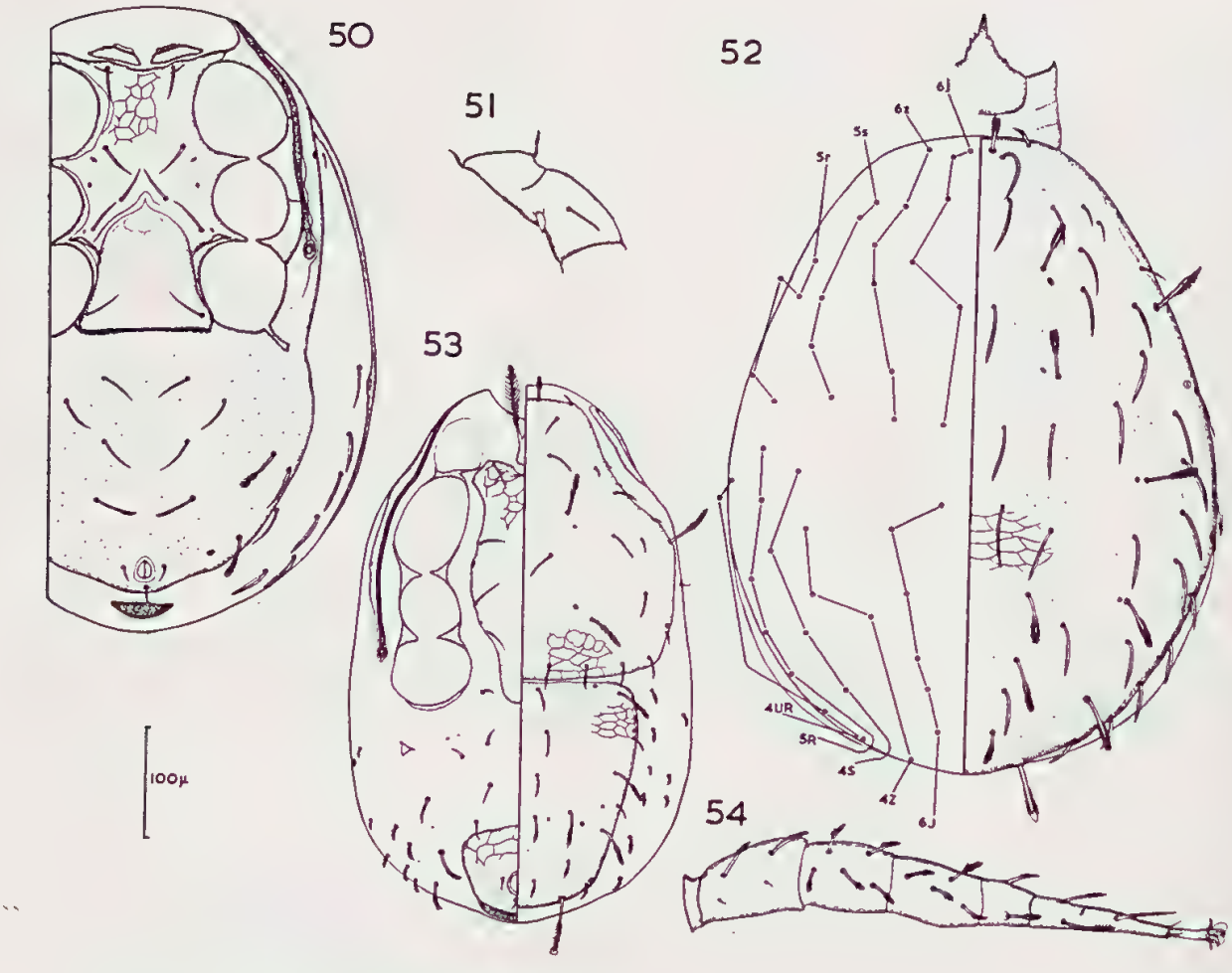


Fig. 50-54. *Ologamasus virgosus* sp. nov.

Fig. 50. Venter of female.
Fig. 51. Venter of femur IV of female.
Fig. 52. Dorsum of female.
Fig. 53. Venter and dorsum of deutonymph.
Fig. 54. Dorsum of distal segments from leg IV of female.

ACKNOWLEDGMENTS

I am indebted to Messrs. D. C. M. Manson and E. D. Pritchard of New Zealand, and to Dr. R. V. Southcott and Messrs. N. B. Tindale, G. F. Gross and P. F. Aitken of the South Australian Museum for collecting the mites described in this paper. Also, I would like to thank Dr. G. Owen Evans of the British Museum (Natural History) and Mr. G. C. Loots of the Potchefstroom University, for their helpful correspondence, and Mr. G. F. Gross for translating Italian.

REFERENCES

Berlese, A., 1888: Acari Austro-Americani. Bull. Soc. ent. Ital., 20: 171-222.

———— 1914: Acari nouvi IX. Redia, 10: 113-150.

———— 1916: Centuria Secunda di Acari Nouvi. Redia, 12: 125-177.

Evans, G. O., 1957: An introduction to the British Mesostigmata (Acarina) with keys to families and genera. J. Linn. Soc. Lond., 43: 203-259.

———— 1963: Observations on the chaetotaxy of the legs in the free-living Gamasina (Acari: Mesostigmata). Bull. Brit. Mus. (nat. Hist.) Zool., 10(5): 275-303.

———— 1964: Some observations on the chaetotaxy of the pedipalps in the Mesostigmata (Acari). Ann. Mag. Nat. Hist., (13)6: 513-527.

Lindquist, E. E. and Evans, G. O., 1965: Taxonomic concepts in the Ascidae with a modified setal nomenclature for the idiosoma of the Gamasina (Acari: Mesostigmata). Mem. ent. Soc. Canada (in press).

Ryke, P. A., 1962a: The subfamily Rhodacarinae with notes on a new subfamily Ologamasinae (Acarina: Rhodacaridae). Entom. Berich., 22: 155-162.

———— 1962b: A revision on the subgenera *Cyrtolaelaps* Berlese and *Gamasellus* Berlese and descriptions of new species (Acarina: Rhodacaridae). Mem. ent. Soc. S. Afr., 7: 1-59.

Sheals, J. G., 1962: Mesostigmata: Gamasina (Acari). Biol. l'Amérique Australe, 1: 83-110.

Trägårdh, I., 1907: The Acaria of the Swedish South Polar Expedition. Wiss. Ergebn. schwed. Sudpolarexped., 5 (Zool., 11): 1-34.

Womersley, H., 1942: Additions to the Acarina-Parasitoidea of Australia. Trans. roy. Soc. S. Austr., 66: 142-171.

———— 1956: Some additions to the Acarina-Mesostigmata of Australia. Trans. roy. Soc. S. Austr., 79: 104-120.

———— 1961: New species of Acarina from the inter-tidal zone in Netherlands New Guinea. Zool. Meded., 37(12): 189-209.

ZUSAMMENFASSUNG

Ologamasus Berlese, ist als solche wieder-definiert und wird als der Gattung *Cyrtolaelaps* Berlese nahestehend betrachtet. Ein Schlüssel wurden ausgearbeitet für die Bestimmung bekannter Adulten von zwölf, neuen Spezies der Gattung *Ologamasus*. Der folgenden neuen Spezies, die zu drei Gruppen gehören, wurden beschreiben: von Neusseeland, *Ologamasus cymosus, mansoni, leptosceles, dumosus, nucilis* und *validus*; von Australien, *O. pyrenoides, discutatus, litoprothrix, tindalei, southcotti* und *virgosus*.

ABORIGINAL CAMP-SITE ON THE STURT RIVER AT COROMANDEL VALLEY, SOUTH AUSTRALIA

By ROBERT EDWARDS, Curator of Anthropology,
South Australian Museum

Text fig.

SUMMARY

This paper records a former aboriginal camp-site overlooking the Sturt River at Coromandel Valley, South Australia. Large stone implements collected on the site are described, figured and compared with similar trimmed cores from another site on the Sturt River and one at Hallett Cove.

Sand quarry operations have now obliterated the site. The implements described in this paper are the only surviving relics of aboriginal occupation of this area.

INTRODUCTION

A sand quarry is located on a ridge near the junction of the Sturt River and Chambers Creek at Coromandel Valley (map, fig. 1). During a visit to this quarry, Mr. F. K. Archibald of Blackwood noticed a number of untrimmed quartzite flakes lying on the surface. On subsequent visits by Mr. Archibald and the writer—over a period 1962-65—an interesting collection of stone implements was made, including some large trimmed cores.

Quarrying activities were responsible for the removal of the surface vegetation from an area of some five acres so permitting wind erosion. The continual displacement of sand revealed stone implements, both in the quarry and on the hard, clay surface which underlies the sand deposit. There is no possibility of dating the artifacts collected as any stratification was destroyed by the quarrying and erosion. Examination of the adjoining region shows that there is a surface layer of whitish sand ranging from 2 to 4 feet in depth. Underlying this is a thicker deposit of clean red sand some 6 feet deep. This sand is very suitable for building operations. The complete obliteration of the camp-site now disposes of any likelihood of further collection of archaeological material.

The observations of Mr. Archibald have fortunately provided the significant collection of implements indicating the location of a former camp-site and showing evidence of the type of implements used.

ABORIGINAL OCCUPATION

The Sturt River and Chambers Creek are semi-permanent streams providing drainage for the surrounding hills area having an annual average rainfall of over 30 inches. During the summer months, springs in the bed of the two streams provide a small but permanent supply of water now used by local orchardists for irrigation. Reports

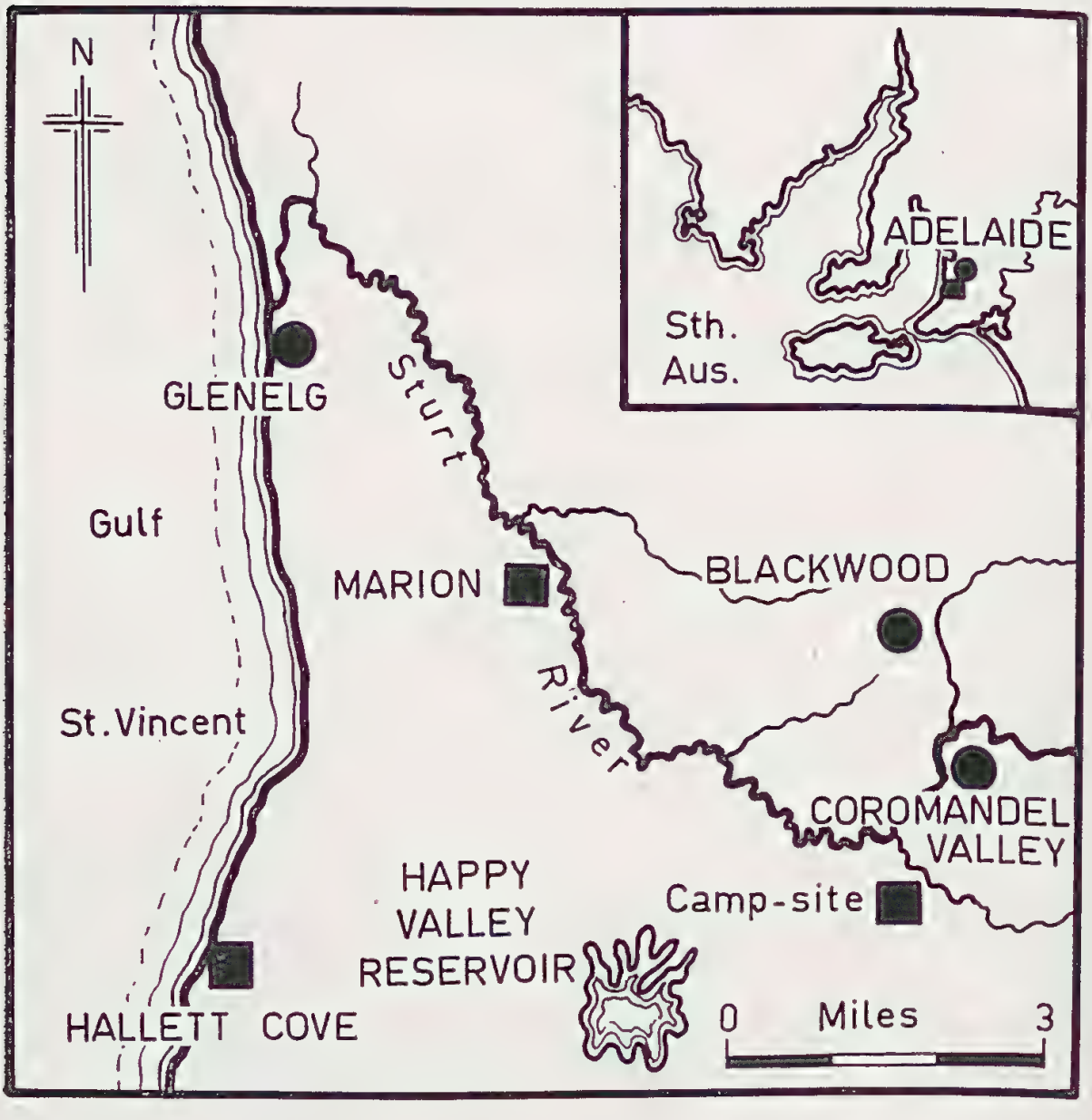


Fig.1. Map showing location of former aboriginal camp-site near the Sturt River at Coromandel Valley

of 1842 (Gr. Btn. Parl.) provide evidence of abundant water in the Sturt River when aboriginals were known to occupy the adjacent region.

In 1848, Mr. Archibald's grandfather, Mr. J. Turner, settled on the large estate still occupied by the family at Blackwood. The Sturt River runs through this property. Accounts of aboriginals camping along its banks in the early days of settlement are recalled by members of the family.

Edwards (1964) records aboriginal occupation of an area near the Sturt River on the Adelaide Plains (map, fig. 1). This could have been their winter camp, as habitation along the River, particularly during the cold winter months, would tend to be away from the hills to the adjoining plains where conditions were more amenable.

STONE IMPLEMENTS

A total of 127 artifacts and 83 discarded, untrimmed flakes were collected on the Coromandel Valley site. Four pieces of slate likely to be portions of reniform skin scrapers (Edwards, 1963), two fragments of red ochre and three rock crystals were also found. All of these were collected from the hard clay horizon exposed by the removal of sand by quarrying activities and wind erosion.

The collection is not extensive, but is of interest as it contains 15 large trimmed core implements (see fig. 2 for typical examples) of a type found elsewhere in South Australia (Cooper, 1943, 1961) and believed to be of some antiquity.

The smaller implements were made from fine-grained quartzite (66 specimens) and milky quartz (38 specimens). These materials are readily available in the nearby creeks. The implements comprise hammerstones, flaking cores, semi-discoids, concaves, terminal and margin trimmed flakes and trimmed irregular pieces. These implements have been compared with others from camp-sites on the Sturt River (Edwards 1964), Moana (S.A. Museum collection) and the type specimens figured by Howchin (1934). All are similar in form, material and type of trimming and can be attributed to the Kaurna (Adelaide) Tribe.

The larger trimmed core implements are identical to those belonging to the industry given the name *Kartan* in South Australia. Edwards (1964) recorded this type of implement from the Marion camp-site. Cooper (1959) also figures these large trimmed cores from the coastal site at Hallett Cove (map, fig. 1). There appears to be evidence to suggest that the occupation and relationship between these sites—indicated by the similarity of smaller implements—have persisted over an extended period.

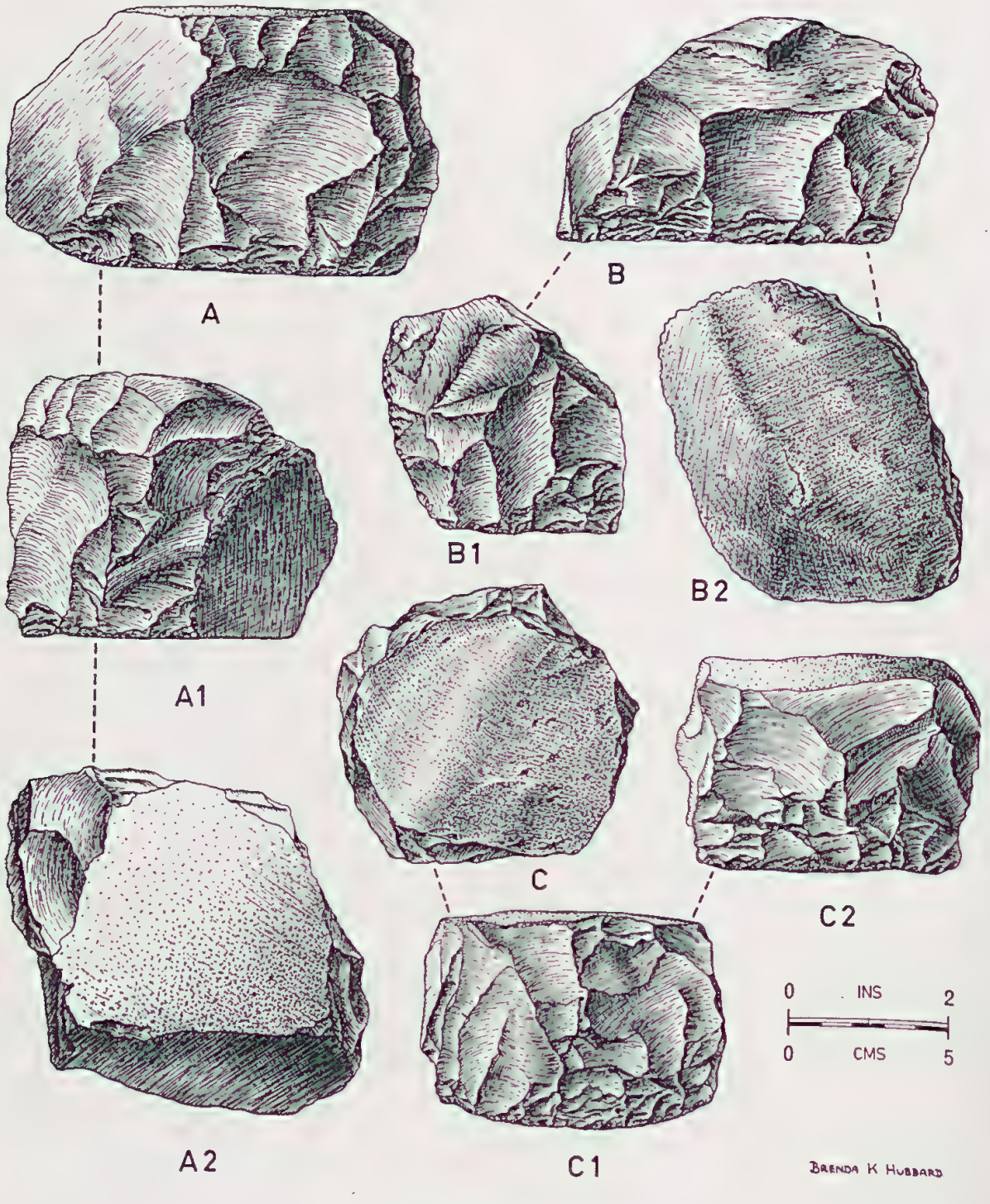


Figure. 2.

Howchin (1934) describes the existence of deposits of fluviatile sands in the Blackwood-Happy Valley Districts. As the aboriginals showed preference for sandy camping places, the occurrence of other archaeological sites may be anticipated for this area and intensive investigations are needed for the collection of examples of the stone

industries of the Kaurna Tribe before the Adelaide Metropolitan area extends over their former territory and disperses all evidence of previous aboriginal activities.

ACKNOWLEDGMENTS

The interest and active assistance of Mr. F. K. Archibald made this paper possible.

The stone implements collected have been donated to the South Australian Museum.

Thanks are expressed to Miss Brenda Hubbard for preparing the text figures of implements.

REFERENCES

Cooper, H. M., 1945: Large Stone Implements from South Australia. Rec. S. Aust. Mus., Adelaide, 7(4).

———— 1959: Large Archaeological Stone Implements from Hallett Cove, South Australia. Trans. R. Soc. S. Aust., Adelaide, 82.

———— 1961: Archaeological Stone Implements along the Lower River Wakefield, South Australia. Trans. R. Soc. S. Aust., Adelaide, 84.

Edwards, R., 1963: Preliminary Survey of the Aboriginal Reniform Slate Scrapers of South Australia. Rec. S. Aust. Mus., Adelaide. 14(3).

———— 1964: A Former Aboriginal Camp-site on the Sturt River at Marion, South Australia. Mankind, Sydney, 6(4).

Howchin, W., 1934: *The Stone Implements of the Adelaide Tribe of Aboriginals.* Adelaide.

Great Britain Parliament, 1843: Papers relative to South Australia presented to both Houses of Parliament, London.

RESUME

On signale pour la première fois les vestiges d'un ancien camp, au bord de la rivière Sturt, à Coromandel Valley, en Australie du Sud. Ces outils en pierre, trouvés dans un chantier, devenu sur le tard sablière, sont les seuls de leur genre trouvés dans ce territoire. Cette étude systématique et illustrée dresse une comparaison entre ces outils et d'autres provenant des sites au bord de la même rivière et à Hallett Cove.

EXPLANATION OF FIG. 2

Examples of the Large Trimmed Core Implements from the Coromandel Valley Camp-site.

A-A1-A2. Massive core implement manufactured from a large block of quartzite. There are two main functional margins roughly at right angles to one another. Specimen Reg. No. A56105 in South Australian Museum.

B-B1-B2. Core implements made from a water-worn angular pebble. The functional margin extends around the periphery of the tool. The natural smooth surface of the original pebble has been retained on the underside of the implement. A56106.

C-C1-C2. Trimmed core implement with step-trimmed functional margin around the base. Re-touching as a result of wear is evident. There are indications of a well-worn working edge around the top of the implement. A56107.

AUSTRALITES USED FOR ABORIGINAL IMPLEMENTS IN SOUTH AUSTRALIA

By ROBERT EDWARDS, Curator of Anthropology,
South Australian Museum

Plates and text fig.

SUMMARY

This paper records the occurrence of implements made from australites in South Australia. Specimens in the South Australian Museum and private collections are listed. The composition of australites and their suitability for use in implement production is discussed. Examples are figured and the distribution considered.

INTRODUCTION

Tektites, small bodies of silica-rich glass thought to be of extra-terrestrial origin, are found in a number of widely separated areas of the earth's surface and named according to the main sites of occurrence. The Australian tektites are known as australites and were first recorded by Charles Darwin in 1844. They show a patchy distribution over the southern half of the continent and are believed to have fallen some thousands of years ago. Extensive collections have been made. The largest, numbering over 18,000, is in the South Australian Museum. The recent developments in space research have focussed attention on the idea of australites having a lunar origin. This has led to more intensive collecting and study of these interesting objects.

Australites are black in colour, frequently have a distinctive pitted posterior surface and are usually round, oval, boat-shaped, canoe-shaped or dumbbell in form (Fenner, 1934). These special features must have attracted the attention of the aboriginals who made use of australites in magic, ceremony and medicine over a wide area of southern and central Australia (Baker, 1957). In places these traditional practices still persist. While at Yuendumu Settlement—situated in the north-west of Central Australia—during August 1965, the writer was told of an incident showing the present day persistence of the aboriginal custom of using australites to cure sickness. The informant was an intelligent aboriginal, 20 years of age, who stated that recently when lying sick in his shelter, he was visited by an elderly woman. From a small bag she reverently took out a number of australites, rubbed them with fat and placed them in rows across his chest. During these procedures she chanted aboriginal songs which apparently were an essential part of the treatment. The next morning

his condition was much improved. But the young man said he considered a penicillin injection had effected the change, rather than the medical "magic" of the native woman. This incident has an added note of interest in that the treatment was carried out by an elderly female, whereas it has generally been recorded that these practices were the skill of the tribal "medicine man". Enquiries at the time about the use of australites in native treatment of sickness provided no satisfactory information for it is apparently a closely kept secret. Such customs had considerable psychological influence over these primitive people in past times.

Anthropologists have also recognized the use of australite glass by the aboriginals as a material for implements (Baker, 1957). Complete australites, flakes, chips and broken pieces have been found on camp-sites. Some have been identified as microlithic implements identical in form to types made from conventional stone materials.

A census has been made of specimens in the South Australian Museum and several private collections. It must be assumed that general collections of australites also contain many specimens that were collected from camp-site areas by people who would have been unaware of the association of the specimens with aboriginal activities. Where specific information was available indicating the likelihood of an aboriginal source, the examples are classified as follows:—

Complete specimens: those showing the natural form of the australites and believed to have been used in aboriginal "magic".

Fractured specimens: pieces having flaked areas but without purposive trimming.

Trimmed pieces: those with fractured areas and marginal trimming but of indefinite shape.

Implements: specimens with secondary trimming and similar in form to the stone microliths of particular types.

Of a total of 443 specimens, approximately 29% are complete australites, 36% are fractured specimens, 13% are trimmed pieces, and 22% are implements. The amount of secondary trimming on definite implements and on the trimmed pieces varies considerably. Some have only four or five flake scars (plate 1 L, M: plate 2 G, H); others have well formed functional margins (plate 1 A, B, E to K, P, Q). The untrimmed, fractured specimens range in size from minute to large pieces (plate 2 E, F). Most of these are flakes with a well developed bulb of percussion. Since they were collected on former camp-sites they probably were produced by human agency. Some are small cores having indications of flake removal (plate 2 A, B)

AUSTRALITES FOUND ON CAMP-SITES IN SOUTH AUSTRALIA.

Locality.	Complete australites.	Fractured specimens.	Trimmed Pieces.	Implements.
Arcoona	81	9		
Bimbowie (Olary)		2		1
Bordertown			1	
Canewood		11	1	2
Corella (Pine Creek)		15	14	8
Edeowie	2			
Glenorchy	1	3	1	
Kalabity	5		1	2
Kenmore Park		2		
Ketchowla		3	1	4
Lake Wilson	13	1	2	
Leigh Creek				1
Lyndhurst	1			
Moonta		18		1
Morialpa				1
Musgrave Park	2	9	3	3
Nackara Springs	1	2		1
Oakvale		2	4	14
Olary	1	3	1	1
Old Whydown	1	4		
Panaramitee		3		2
Parcoola		2		1
Pine Creek (Burra)		5	4	9
Pine Valley	2	14	2	4
Pitcairn	3	1		2
Pt. Riley		1		
Tomkinson Range				1
Waroonie	1			1
Wiawera	15	51	21	37
Winnininnie	1			
Total	130	161	56	96

FRACTURING PROPERTIES OF AUSTRALITE GLASS

Australite glass breaks with a pronounced conchoidal fracture, the bulb of percussion and negative scar being usually well developed as also are the radiating and concentric ripple lines. All of these features result from the mechanics of fracture and are more obvious in this than in those materials generally used for stone implements.

A readily obtainable, clear fracture is not the only desirable quality in a material used for implements. Structural toughness is essential for the maintenance of a good functional margin and this quality is lacking in the brittle, glassy nature of the australite. Through long experience, the aboriginal learnt to maintain a strong working margin of his stone tools by trimming a bevel which provided a supporting mass of material to the requisite sharpness of the working edge of the tool.

Another factor limiting the use of australites as a material for implements is their small size. Although a few have been found up

to 85mm in length, the majority are between 20 and 30mm and weigh 5 to 10gm. Their small size and brittle nature limited the usefulness of australite glass compared with fine grained forms of chalcedony materials like porcellanite, agate, and jasper which were used extensively in certain areas. Australites obviously held a very minor place as a suitable material for implements, but nevertheless, a number of interesting examples have been found.

ANTIQUITY

When a dating of the terrestrial deposits of australites from outer space has been established, it will give some indication of when they were first recognized and used by the aboriginal. Gill (1965) has reported the finding of australites in a selected site excavated at Port Campbell on the south coast of western Victoria. Fourteen specimens were discovered *in situ* associated with material suitable for radiocarbon dating. The specimens were found amid horizons ranging between 4830 ± 250 and 5700 ± 350 B.P. (before 1950). There is no indication in this report that any of the examples had been fractured or trimmed in any way.

Although australite implements are microlithic, this may not be of technological significance as the small size of the available raw material was obviously a definite limiting factor. Tindale (1957) has assigned microlithic implements to his Mudukian culture of the general period 3,800-2,000 years ago, on the lower Murray River. Australite implements may have been made during this period when microliths were predominant. The trimmed forms of australites occur as microlithic discoids (plate 1, E to H), semi-discoids (plate 1 J, N), terminal trimmed flakes (plate 1 A, B) and even re-touched implements (plate 1 P, O), indicating conformity with some of the well known microlithic forms.

There is insufficient evidence at the present time to permit the dating of australites used as implements. The discovery of trimmed specimens *in situ* with associated material that could be radiocarbon dated may help to clarify the problem.

DISTRIBUTION

Collections of australite implements have mainly been limited to a few specimens from widely separated sites, so that no particular distribution was indicated. In more recent times, experienced collectors, recognizing their importance, have deliberately looked for and found specimens in significant numbers. Mr. and Mrs. K. Treloar have found 37 implements on their Wiawera Station (map, fig. 1):

J. E. Johnson (1963) collected numerous specimens from Corella Station near Cockburn, on Yorke Peninsula and in the north-west of South Australia: M. Mudie, of Arcoona Station, has 81 complete

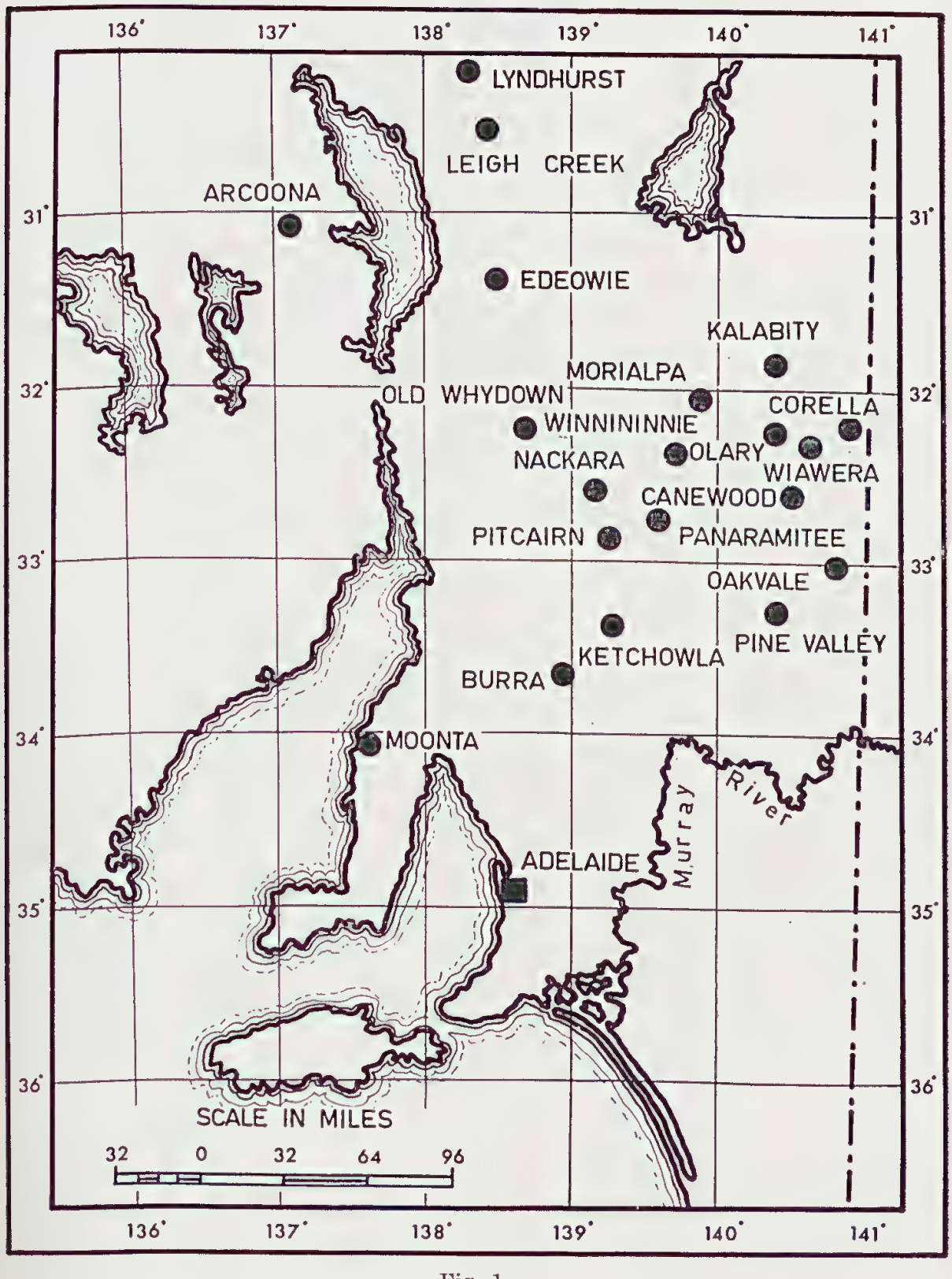


Fig. 1.

australites and nine fractured pieces from sites on that Station. The present writer has made systematic searches for these implements and found them at eleven localities in the north-east of this State.

Continued attention to the occurrence of these small objects among the material on aboriginal sites will help to establish the extent and mode of their distribution. However, a study of present available collections has enabled some tentative observations to be made on this aspect of the subject. The main australite implement finds in South Australia extend over a region between the River Murray and the Peterborough-Broken Hill railway line (map, fig. 1) where good quality stone for implements is practically non-existent and usually obtained by trade. In the Lake Torrens and Lake Eyre regions, abundant supplies of suitable stone are readily available. Australite specimens collected from camp-sites in such areas are generally intact and untrimmed and were possibly used by the aboriginal in his practice of "magic" (plate 2, I to N). It may be that the availability of stone for implements influenced the use of australite glass.

The distribution of australites not associated with aboriginal camp-sites has been the subject of intensive study (Baker, 1959). Mapped concentrations could include areas covered by informed collectors. Barnes (O'Keefe, 1963) suggests the sporadic finds made between areas of major accumulations were probably carried there by aboriginals or in the gizzards of large birds such as the emu.

The australites in use at Yuendumu in Central Australia were said by the aboriginals to have come from a great distance and were possibly transported by them from the Musgrave Park or Mount Davies-Lake Wilson areas where numerous specimens have been recovered. The dispersal of australites from their original strewn-fields can be attributed to many agencies. There is insufficient evidence to indicate whether their use by the aboriginals had any significant effect on their distribution.

The work of Johnson (1964) in the Wingellina-Hinckley Range area just over the Western Australia-South Australia border beyond Mount Davies, and that of Baker (1957) in western Victoria is indicative of an area of distribution for australite implements extending far beyond South Australia.

CONCLUSION

The Australian aboriginal used australites in mythology and for the manufacture of implements. The latter use appears to be of minor importance and mainly confined to areas where suitable stone materials are in short supply. Use in mythology is wide-spread as the comparative rarity and distinctive appearance of australites would have made

them highly desirable for this purpose. It seems likely that apart from the recognized fracture quality of australites as a material for use as small implements, the main factor in its attractiveness to the aboriginal was similar to that of modern man—something as unusual as terrestrial objects and material.

The present notes list the occurrences and discuss their apparent significance. It is hoped further attention will be directed to the archaeological aspect of australites and encourage research and collecting, thus contributing to the study of this interesting aspect of aboriginal life.

ACKNOWLEDGMENTS

Appreciation is expressed to Dr. T. D. Campbell and Mr. D. A. Casey, whose encouragement led to the writing of this paper.

The advice of Mr. Edmund D. Gill, Drs. George Baker, P. S. Hossfeld and D. W. Corbett was invaluable.

The following people kindly permitted examination of their collections: Mr. and Mrs. K. Treloar, Mr. and Mrs. R. D. J. Weathersbee, Dr. G. Gregory, Messrs. M. Mudie, Brian Sawers, Andrew Bailey and B. O'Connell. Mr. J. E. Johnson has donated his collection to the South Australian Museum.

Mr. Denis Marfleet assisted with the photographing of the australite specimens.

REFERENCES

Baker, George, 1957: The rôle of Australites in Aboriginal Customs. Mem. natn. Mus., Melb., 22(8).

———— 1959: Tektites. Mem. natn. Mus., Melb., 23.

Fenner, Charles, 1935: Australites, Part II. Numbers, forms, distribution and origin. Trans. R. Soc. S. Aust., Adelaide, 59.

Gill, Edmund D., 1965: Quaternary Geology, Radiocarbon Dating, and the Age of Australites. Bull. geol. Soc. Am., Rochester. N.Y., 84.

Johnson, J. E., 1963: Observations on some aboriginal campsites in South Australia and adjoining States. Part 1. Mankind, Sydney, 6(2).

———— 1964: Observations on some aboriginal campsites in South Australia and adjoining States. Part 2. Mankind, Sydney, 6(4).

O'Keefe, John A., 1963: *Tektites.* Chicago.

Tindale, Norman B., 1957: Culture Succession in South-eastern Australia from Late Pleistocene to the Present. Rec. S. Aust. Mus., Adelaide, 13(1).

ZUSAMMENFASSUNG

Die vorliegende Thesis behandelt die von Australiten gefertigten Gerätevorkommen in Sudaustralien.

Exemplare des Museums von Sudaustraliens wie auch solche aus privaten Sammlungen sind angefuhrt.

Ebenfalls berücksichtigt sind die Zusammenstellung der Australiten sowie deren Brauchbarkeit fur die Geräte-herstellung.

Die Exemplare sind nummeriert und deren Verbreitung in Betracht gezogen.

EXPLANATION OF PLATES 1 TO 2

PLATE 1

Views of Both Outer and Inner Faces of Each Implement.

Fig. A. B. Flake with end trimming. Most of the outer surface of the australite has been removed during the manufacture of the implement. Locality: Pitcairn Station, South Australia.

Fig. C. D. Trimmed core implement made from the central core portion of a worn australite. The surface shows differential weathering (fig. D) suggesting two periods of use. The high vitreous lustre of some flake scars is evidence of recent trimming. This could be accidental rather than archaeological and purposely produced. Locality: Ketchowla, South Australia.

Fig. E. F. Discoidal flake, margin trimmed. Typical bubble pitted outer surface can be seen on fig. E. Locality: Ketchowla, South Australia.

Fig. G. H. Discoidal flake with steeply trimmed functional margin. The conchoidal fracture is distinct (fig. H). Locality: Nackara Springs, South Australia.

Fig. I. J. K. Core implement with fine secondary trimming on the margin. Flake scars are weathered (fig. J). Locality: Kalabity Station, South Australia.

Fig. L. M. Simple trimmed flake showing radial and conchoidal fracture lines (fig. M). Locality: Canewood Station, South Australia.

Fig. N. O. Core implement with semi-discoidal trimming. The base has been formed by the removal of two flakes. The concentric ripple fracture lines are pronounced (fig. O). Locality: Kalabity Station, South Australia.

Fig. P. Q. Flake with distal end trimming. Reduced in size by marginal re-touching. Locality: Ketchowla, South Australia.

PLATE 2

Fig. A. B. Core implement with trimmed margin. Irregular in shape. Much of the original australite surface has been retained. Locality: Kalabity Station, South Australia.

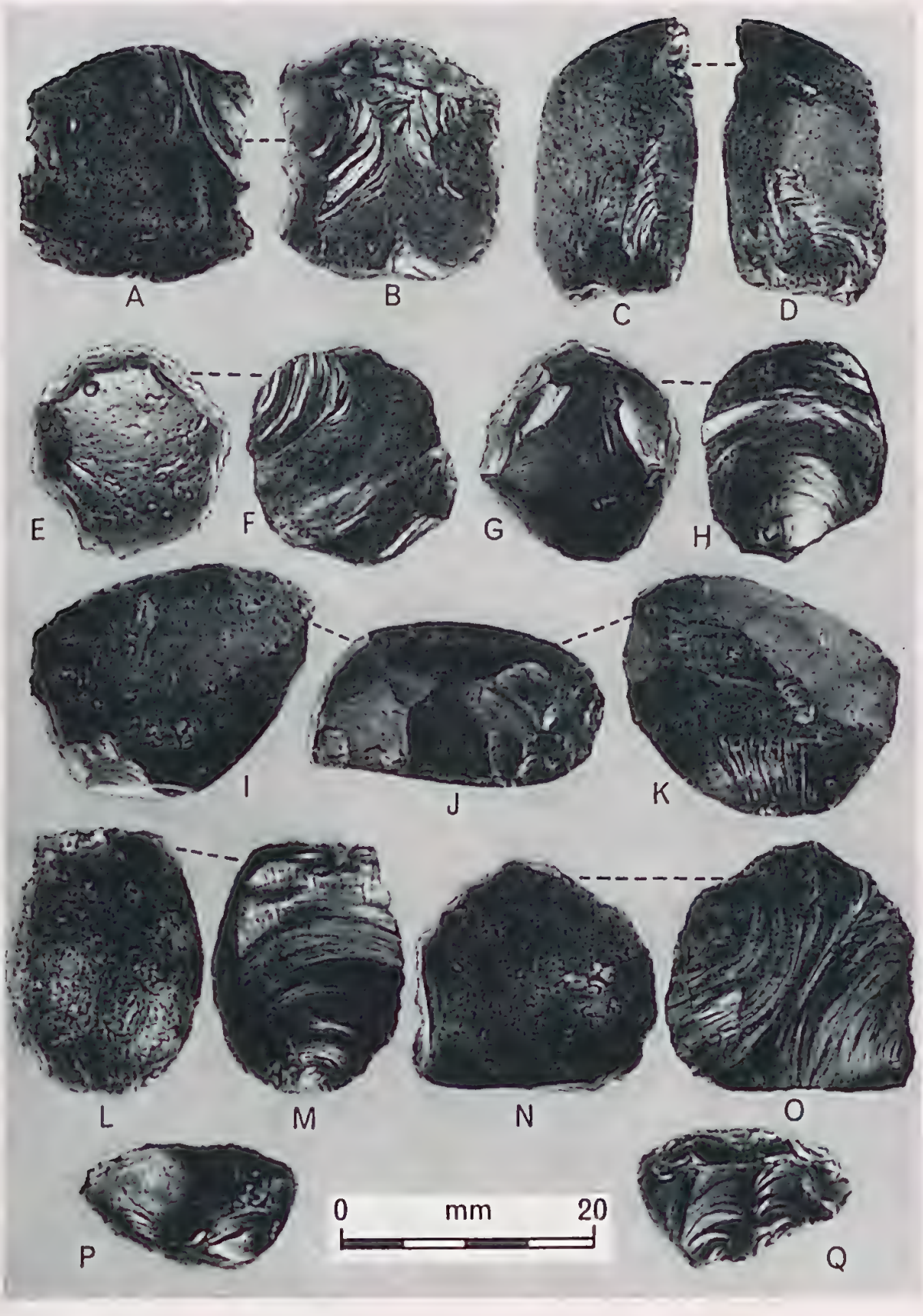
Fig. C. D. A small oval to boat-shaped australite core found on an aboriginal camp-site. Locality: Kalabity Station, South Australia.

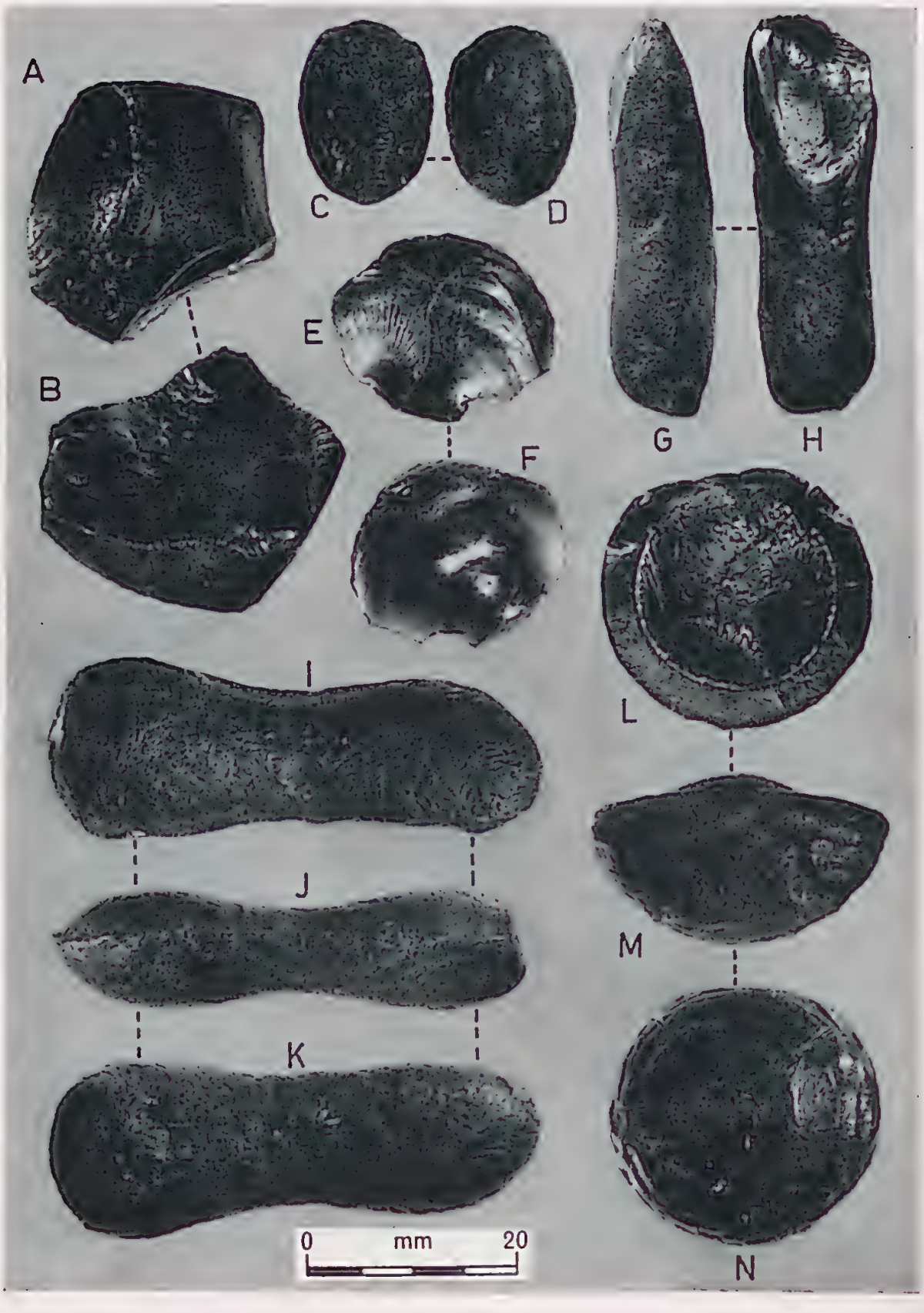
Fig. E. F. Flake with distinctive conchoidal fracture and lines radiating from the point of impact (fig. E). Flakes have been removed from the butt end of the outer face. Locality: Canewood Station, South Australia.

Fig. G. H. Worn dumbbell-shaped australite with terminal flakes removed to produce a working margin. Locality: Canewood Station, South Australia.

Fig. I. J. K. Dumbbell-shaped australite found on an aboriginal camp-site. The circumferential flange has been lost. The distinctive shape is believed to be pre-determined before atmospheric entry. Locality: Arcoona Station, South Australia.

Fig. L. M. N. Flanged australite. This form is rare. The flow ridges on the anterior surface (fig. M and N) are partly visible; close examination of the specimen reveals that these ridges are concentric in character. Locality: Arcoona Station, South Australia.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
0 mm 20


A
B
C
D
E
F
G
H
I
J
K
L
M
N
0 mm 20

ZOILA MARGINATA (MOLLUSCA, CYPRAEIDAE) IN SOUTH AUSTRALIA

By HELENE M. LAWS, Curator of Marine Invertebrates, South Australian Museum

SUMMARY

Three specimens of *Zoila marginata* (Gaskoin, 1848), recently rediscovered in Western Australia, have been found in South Australia, one at Cape Jervis and one each at Taylor Island and Grindal Island near Port Lincoln. The specimens are described and the range of *Z. marginata* and the validity of the species are briefly discussed.

INTRODUCTION

One of the most interesting recent rediscoveries in the Cypraeidae is that of *Zoila marginata* (Gaskoin, 1848). The holotype remained unique for 113 years until Cate (1961) published a description of a second specimen thought to have been trawled in Albany Bay. This locality is, however, open to doubt (Cate, 1964). The only locality given for the holotype is "New Holland" and Cate (1964) has therefore designated Pelsart Island, Houtman Abrolhos Group, as the type locality for the species. Since Cate's description in 1961, of *Z. marginata,* a number of other specimens have been taken off the Houtman Abrolhos Islands and at several other localities in Western Australia (Cate, 1961, 1964; editorial note, Hawaiian Shell News, 1962; Weaver, 1961).

In September, 1962, a live cowrie from Cape Jervis, South Australia, was given to the present owner of the shell, Mr. E. L. Johnson of Adelaide. Comparison of the shell with photographs of the holotype and with published photographs and descriptions have shown it to be *Z. marginata*—the first specimen to be taken in South Australian waters. In November, 1964, a further live specimen was found at Taylor Island near Port Lincoln by a skin diver, Mr. N. Williams; this is the second record of the species in South Australia. Following this discovery Mr. Williams found yet another living specimen off Grindal Island, a few miles from Taylor Island.

DESCRIPTION

The Cape Jervis shell (fig. 1, 2, 3) is creamy in colour and the dorsum is irregularly, but quite densley, blotched with pale brown; spotting on the side is so faint as to be barely discernible. The Taylor Island specimen (fig. 4, 5, 6) is pinkish-cream, whiter where the shell

is thickest, and the dorsal blotching is also pale brown but is very sparse and the right side of the dorsum is almost unmarked. The shell from Grindal Island is similar to that from Taylor Island, but the brown blotching extends over the right side of the dorsum. The columella and the interior of all shells are pink. In addition, all show a feature which has not previously been noted in the literature. On the sides there is a very fine pattern of lighter spotting on a slightly darker background. This is particularly clear in figs. 1 and 4.

All specimens have the exaggerated margins, prominent spire and well developed teeth which are characteristic of *Z. marginata.* Within *Zoila,* only *Z. rosselli* Cotton is comparable in the degree of development of both labial and columellar teeth. Surface concavities which distinguish *Z. marginata* from other known cypraeids, are present on the base and margins producing undulations along the well developed marginal ridges (fig. 3 and 6). The bases of the shells are spotted with brown, the Taylor Island specimen most densely and with very dark brown. In all three, as is characteristic for the species, these spots correspond with concavities of the shell surface. On the labial side of the base the spots and concavities are elongated towards the aperture and in the Taylor Island shell a majority of these concavities are continuous with the hollows between the labial teeth.

Measurements and teeth numbers are given in table I. All animals were taken alive and it is rather surprising that the colour of the Cape Jervis animal was greyish-green while that of the Taylor Island one was pinkish-white. Little is known of the habits and habitat of South Australian specimens. At Cape Jervis the animal was taken in 70-80 feet of water. The Taylor Island specimen was found at a depth of 40 feet crawling on weed on a rocky reef, and the Grindal Island specimen at the same depth.

DISCUSSION

These records of *Zoila marginata* from Cape Jervis, Taylor Island and Grindal Island, South Australia, extend the known range of the species by more than 1,000 miles. The ranges of species and subspecies of *Zoila* are shown on fig. 7 which has been prepared using information from Cate (1964), Wilson (1958), localities of *Zoila* specimens in the South Australian Museum and the new records of *Z. marginata* in South Australia. *Z. marginata* is now known from widely separated localities. It occurs within the ranges of the Western Australian *friendi friendi* (Gray), *f. vercoi* (Schilder), *venusta venusta* (Sowerby), *v. sorrentensis* Schilder and *rosselli* Cotton, and also within that of the southern *thersites* (Gaskoin)

(including *t. contraria* Iredale). This, along with the number of specimens now known, eliminates the possibility that *Z. marginata* might be an abnormality of some other *Zoila* species as suggested by Allan (1956).

ACKNOWLEDGMENTS

The writer wishes to express her thanks to Mr. E. L. Johnson of Adelaide and Mr. N. Williams of Port Lincoln who made their specimens available for study, and to Mr. N. Tebble of the Mollusca Section, British Museum of Natural History, who sent photographs of the holotype for comparison with South Australian specimens. Mr. J. Veitch of Port Lincoln also gave valuable help in the preparation of this paper.

REFERENCES

Allan, Joyce, 1956: *Cowry Shells of World Seas.* Georgian House, Melbourne, 170 pp.

Cate, C. N., 1961: Rediscovery of *Cypraea marginata* Gaskoin, 1848. Veliger, 3: 76-78.

———— 1964: Western Australian cowries. Veliger, 7: 7-29.

Gaskoin, J. S., 1848: Description of new species of the genus *Cypraea.* Proc. zool. Soc. Lond, 1848-1850: 90-91.

Hawaiian Shell News, 1962. Hawaii. Shell News, 10(11): 1.

Weaver, C. S., 1961: Rare shell borrowed and photographed for HSN readers. Hawaii. Shell News, 9(8): 1.

Wilson, B. R., 1958: A deep-water cowrie from the West Coast. West. Aust. Nat., 6: 129.

TABLE I

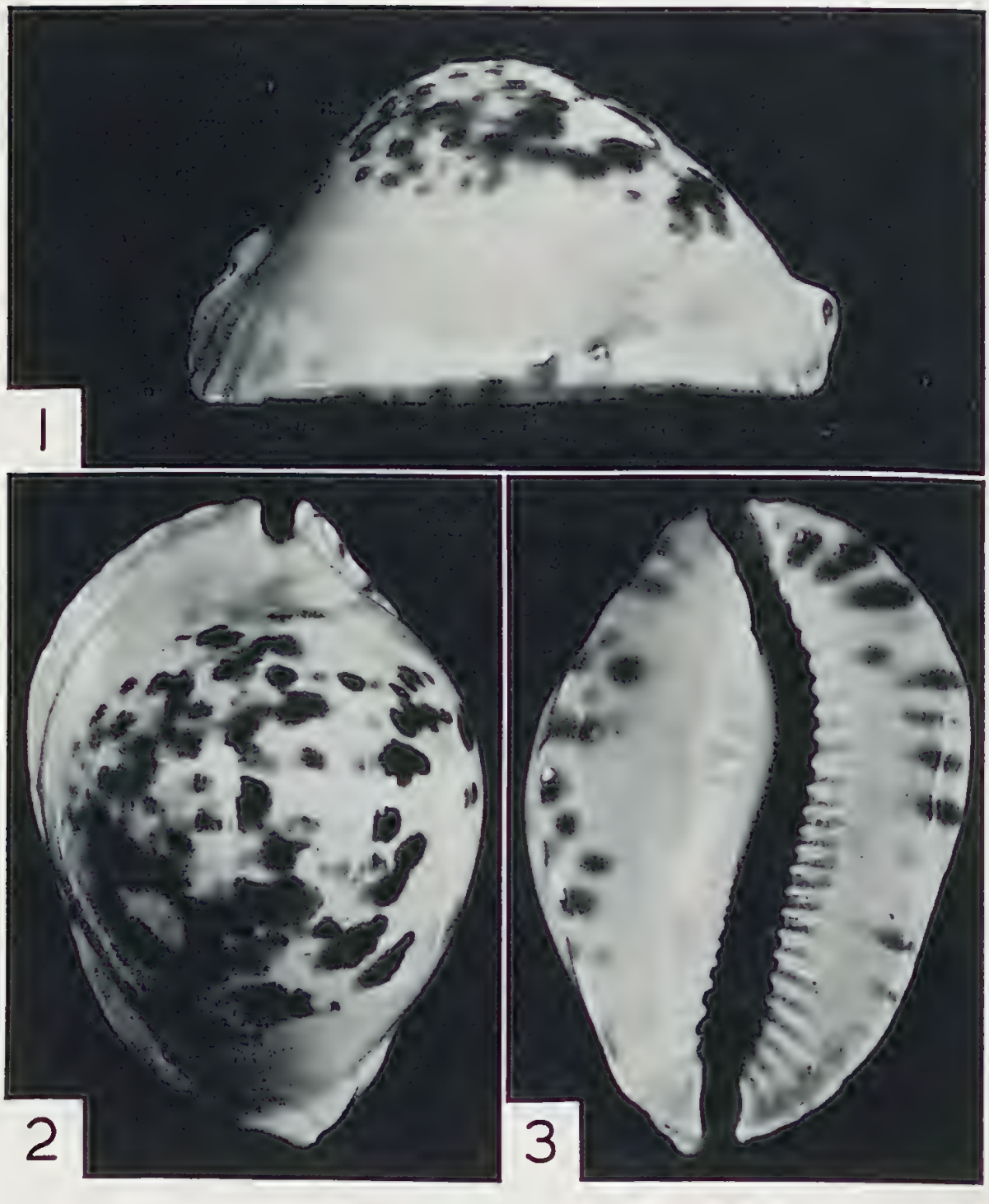
Shell measurements of South Australian *Zoila marginata.*

	Cape Jervis.	Taylor Island.	Grindal Island.
Length (mm)	53	62	57
Width (mm)	36.5	39.5	46
Height (mm)	29	31.5	29
Number of labial teeth	22	26	26
Number of columellar teeth	19	23	19+*

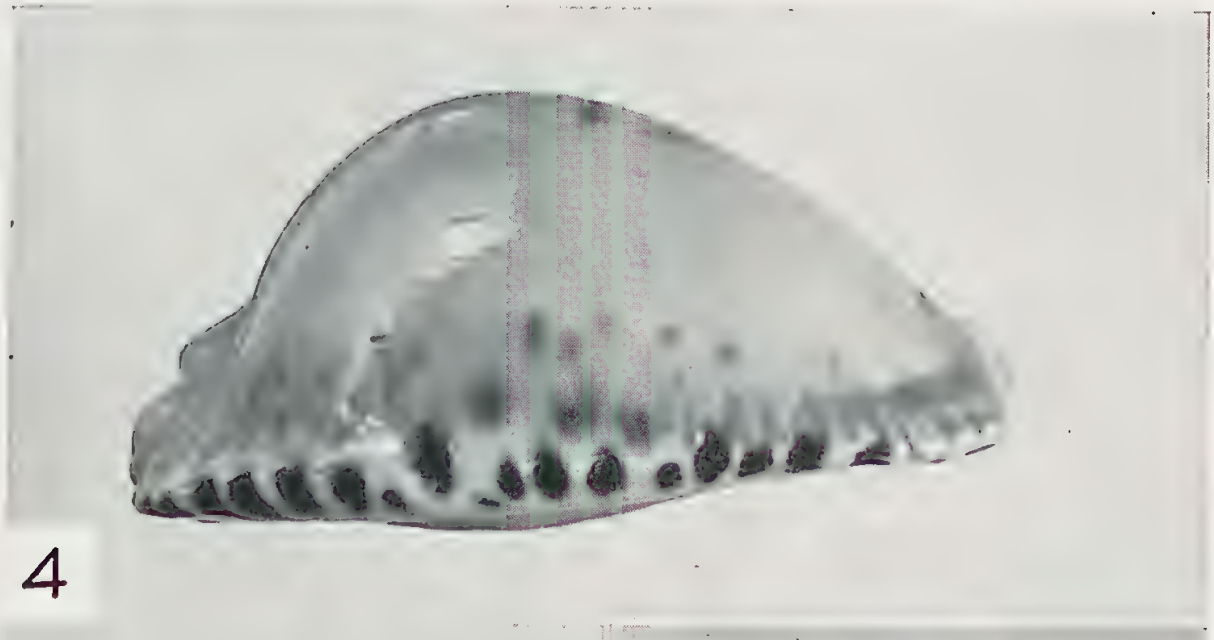
* The Grindal Island shell has been chipped and the posterior columellar teeth are missing.

LEGENDS TO FIGURES

1. *Zoila marginata,* Cape Jervis, right side.
2. *Zoila marginata,* Cape Jervis, dorsal view.
3. *Zoila marginata,* Cape Jervis, ventral view.
4. *Zoila marginata,* Taylor Island, right side.
5. *Zoila marginata,* Taylor Island, dorsal view.
6. *Zoila marginata,* Taylor Island, ventral view.
7. Map showing distribution of *Z. marginata* in relation to known ranges of other species and sub-species of the genus *Zoila.*



Figs. 1, 2, 3.



Figs. 4, 5, 6.

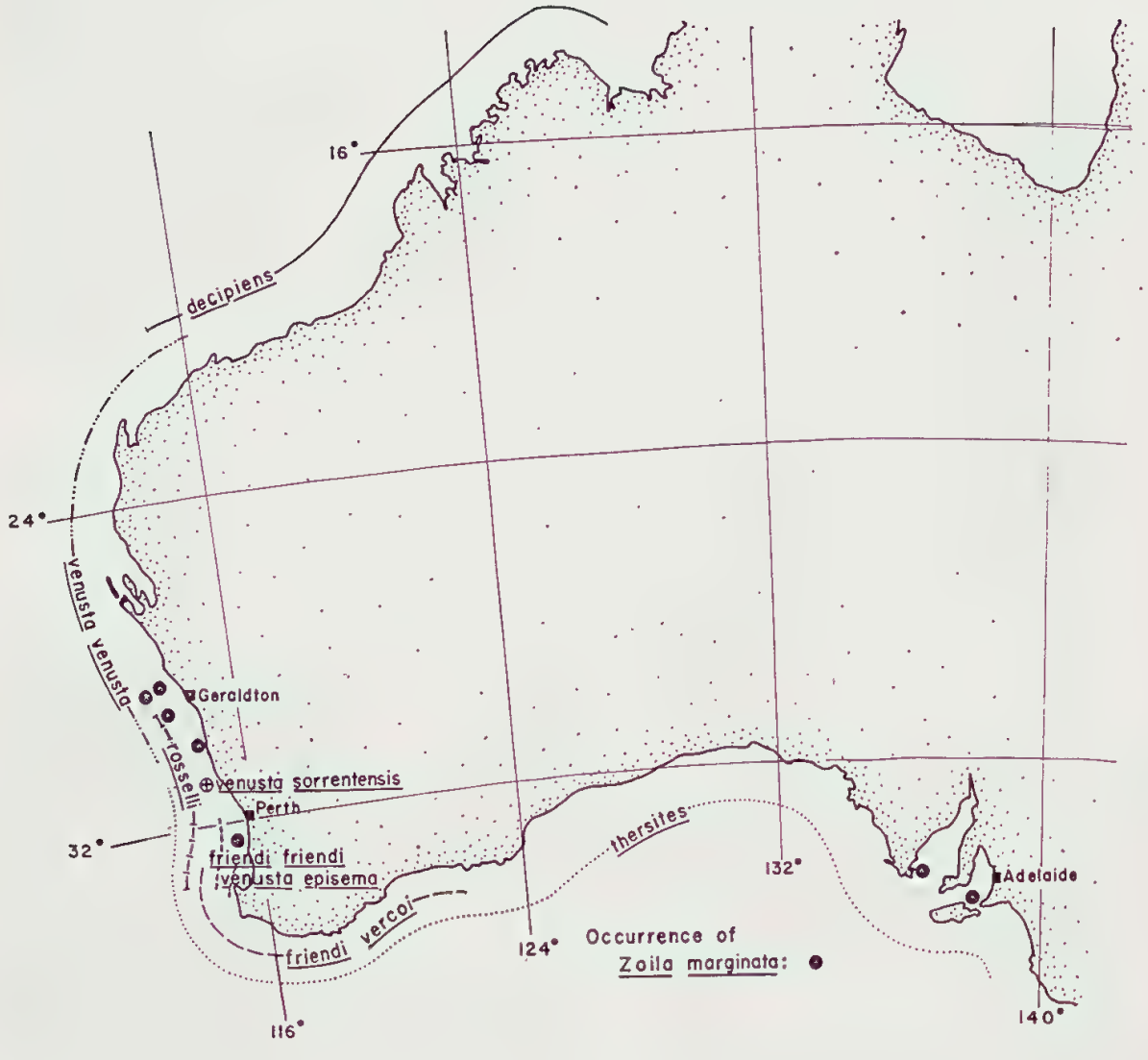

16°
decipiens
24°
venusta venusta
rasselli
Geraldton
venusta sorrentensis
Perth
32°
friendi friendi
venusta episema
friendi vercoi
thersites
116°
124°
132°
Adelaide
140°
Occurrence of
Zoila marginata:

Fig. 7.

THE CYTOLOGY AND ANATOMY OF OXYCHILUS ALLIARIUS (MILLER) (MOLLUSCA, ZONITIDAE), A NEW INTRODUCTION TO SOUTH AUSTRALIA

By HELENE M. LAWS, Curator of Marine Invertebrates,
South Australian Museum

SUMMARY

Oxychilus alliarius (Miller), previously recorded from New South Wales, is now known to occur in South Australia. The radula, reproductive system and chromosomes are described from specimens taken at Glen Osmond, Adelaide, South Australia, in 1965.

INTRODUCTION

Oxychilus alliarius (Miller), a member of the family Zonitidae, is native to central and western Europe and Iceland. It has been introduced into the United States (Burch, 1960; Pilsbry, 1946; Taylor, 1914) where in New York, New Jersey, Colorado, Michigan and California it is a pest of greenhouses and sometimes gardens; it has also been recorded from South Africa (Quick, 1952) and New South Wales (Cotton, 1954).

In June, 1965 snails were collected in quantity from a garden in Glen Osmond, Adelaide, South Australia; these agree most closely with descriptions of *O. alliarius*.

METHODS

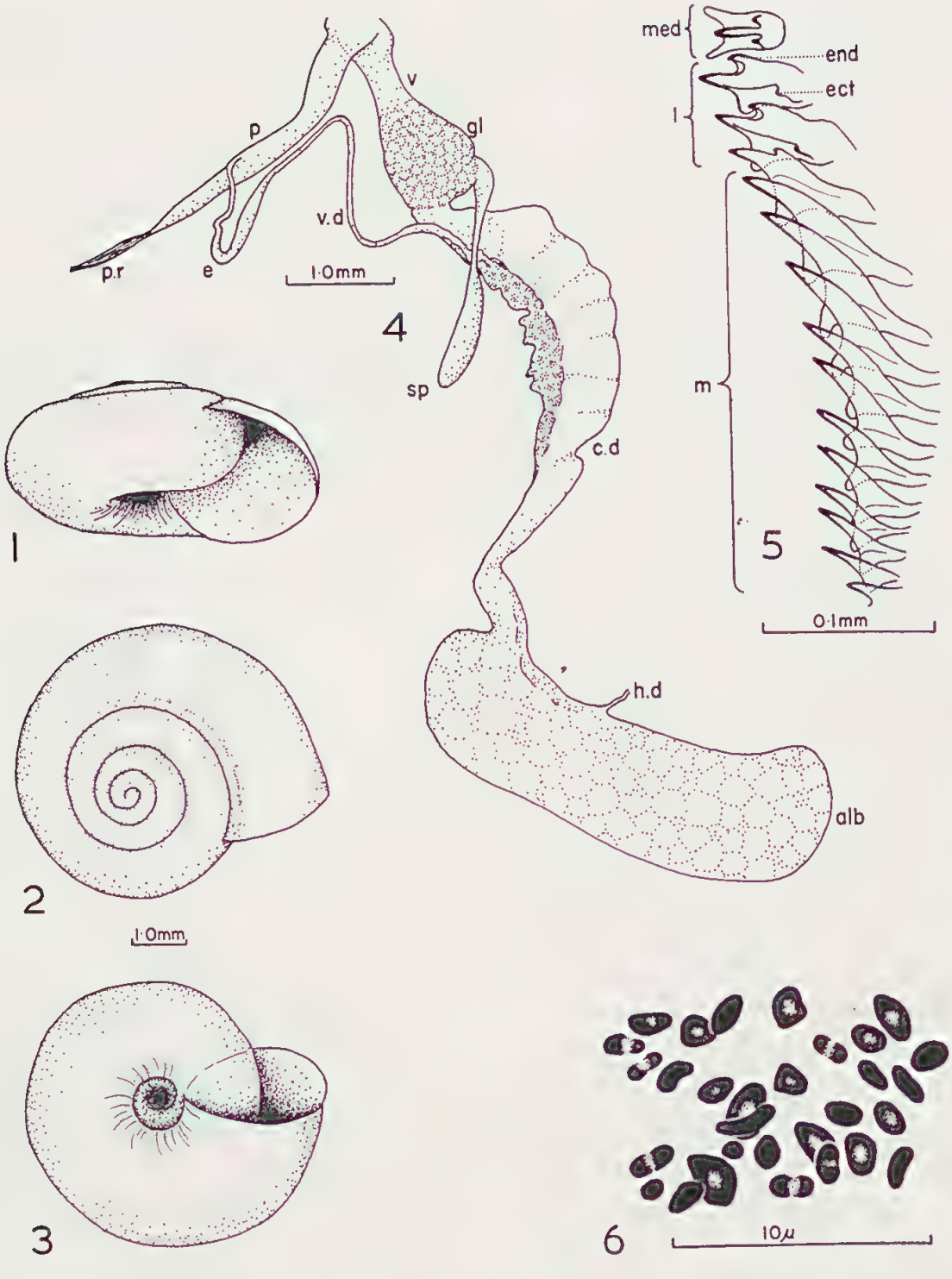
The reproductive system was dissected out from snails drowned overnight in water; it was spread on a slide, held flat by the weight of a second slide, and fixed in Bouin. Staining was with borax carmine (short method; Pantin, 1948) and dehydration followed Gregg's method for pulmonate reproductive systems (1958).

For cytological observations squash preparations were made in aceto-orcein.

Voucher specimens and slides of the radula, reproductive system and chromosomes are in the South Australian Museum collection, Reg. No. D14884.

OBSERVATIONS

The shell (fig. 1-3) is small, highly polished and of a transparent pale amber colour although in life the darkly pigmented body of the animal shows through; the size range for seven specimens is as



LEGEND TO FIGURES

Fig. 1-3. Lateral, dorsal and ventral views of a shell of *Oxychilus alliarius* (Miller).

Fig. 4. Reproductive system of *O. alliarius*:—alb, albumen gland; c.d, common duct; e, epiphallus; gl, glandular tissue; h.d, hermaphrodite duct; p. penis; p.r, penial retractor; sp, spermatheca; v, vagina; v.d, vas deferens.

Fig. 5. Radula of *O. alliarius*:—med, median; l, laterals; m, marginals; ect, ectocone; end, endocone.

Fig. 6. Meiotic chromosomes of *O. alliarius* at diakinesis of spermatogenesis; n = 30.

follows: greatest diameter, 6.0 to 6.7 mm, mean, 6.38 mm; height, 2.8 to 3.3 mm, mean, 3.03 mm. It is depressed and umbilicate (umbilical diameter, 0.8 to 1.2 mm, mean 1.02 mm), the umbilicus clearly showing the penultimate whorl; the aperture is ovate-lunate with a straight and unthickened lip and the last whorl does not descend. There are 4 to 4½ whorls and the sculpture of the shell surface consists of very fine growth lines.

The animal is dark grey on the dorsal surface of the head region and collar, shading to lighter grey and with a pale sole. Pedal and supra-pedal grooves are present and the sole of the foot is faintly tripartite. When disturbed and particularly when the upper visceral whorls were opened for gonad samples, the "inhabitant smells strongly of garlick" (Miller, 1822).

The Radula. The radula (fig. 5) is similar to that shown (Taylor, 1914) for *O. alliarius* but in the Glen Osmond specimens the ectocone of the first and second laterals is a simple, but very reduced, cusp rather than a serrated one, as in Taylor's material. The third lateral is transitional, being very similar to the marginal teeth except for a weakly developed endocone. It is closer to the radular pattern shown by *O. cellarius* (Müller) (Taylor, 1914; Pilsbry, 1946). The radular formula is 11.3.1.3.11.

Reproductive System. In *Oxychilus* the atrium is short and the vagina long by comparison and covered by glandular tissue which also extends over the base of the spermathecal duct; this duct is considerably shorter than the common duct. There is a terminal penial retractor and the epiphallus is inserted well below the apex of the penis. The Glen Osmond material shows all these features (fig. 4) but the spermatheca is more elongate than in Taylor's material.

Cytology. Very few meiotic figures could be obtained from the Glen Osmond specimens and only one snail, of many which were tried, gave a satisfactory chromosome count. The chromosome number from meiosis in primary spermatocytes, is n = 30 (fig. 6). There are two large bivalents and a gradual reduction in size throughout the remaining chromosome pairs; this can also be seen in spermatogonial mitoses although there accurate counts could not be made.

DISCUSSION

The snails described above agree with descriptions of *Oxychilus alliarius* (Miller) in most respects—the size and shape of the shell, number of whorls, broad umbilicus, strong garlic smell and the body pigmentation. They do, however, show two points of difference; the

first and second lateral radular teeth have simple ectocones rather than the serrated cusp described by Taylor. In addition, the spermatheca is elongate rather than oval to spherical. Taylor's observations were, however, made on British material; there is no information available for continental representatives of *O. alliarius*.

With regard to radular and spermathecal anatomy the Glen Osmond specimens come closer to *O. cellarius* (Müller), but the balance of characteristics do tend towards *O. alliarius* and it seems best to regard the South Australian material as belonging to this species.

The collection of *O. alliarius* from Glen Osmond is not, in fact, the first to be made in South Australia. In the South Australian Museum there is a single collection of *O. alliarius* shells made at Linden Park in December, 1962; their identity had not previously been realized.

ACKNOWLEDGMENTS

The author wishes to express her thanks to Miss M. Angel, University of Adelaide, for the Glen Osmond collection of living *Oxychilus alliarius*.

REFERENCES

Burch, J. B., 1960: Some Snails and slugs of quarantine significance to the United States. Sterkiana, 2: 13-53.

Cotton, B. C., 1954: A catalogue of introduced snails and slugs in Australia. Rec. S. Aust. Mus., 11: 177-187.

Gregg, W. O., 1958: A technique for preparing *in toto* mounts of molluscan anatomical dissections (abstract). Rep. Am. malac. Un. Pacif. Div. 1958: 39.

Miller, J. S., 1822: Ann. Philos. (N.S.), 3: 379.

Pantin, C. F. A., 1948: *Notes on microscopical technique for zoologists.* Cambridge University Press, 79 pp.

Pilsbry, H. A., 1946: Land Mollusca of North America (North of Mexico). Monogr. Acad. nat. Sci. Philad. No. 3, Vol. II, Part I.

Quick, H. E., 1953: Helicellids introduced into Australia. Proc. malac. Soc. Lond., 30: 74-79.

Taylor, J. W., 1914: *Monograph of the Land and Freshwater Mollusca of the British Isles, Zonitidae, Endodontidae, Helicidae.* Taylor Brothers, Leeds, 522 pp.

ZUSAMMENFASSUNG

Oxychilus alliarius (Miller) ist in Süd Australien eingeführt worden. Die Chromosomenzahl, in primären Spermatocyten, ist n = 30. Die Anatomie der Geschlechtsorgane und der Radula wird beschrieben.

NEANURID COLLEMBOLA OF AUSTRALIA PRESERVED IN THE SOUTH AUSTRALIAN MUSEUM

By RIOZO YOSHII, Yoshida College, Kyoto University, Japan

SUMMARY

Collembola of the Family Neanuridae of Australia, collected by late Prof. Womersley and preserved in the South Australian Museum have been studied from a new viewpoint. Nine forms including four new species have been detected and a new diagnosis is given for each species.

By the kindness of Mr. D. H. Murphy and Mr. G. F. Gross who have sorted out the Neanurid material of late Prof. H. Womersley, preserved in the South Australian Museum, I was privileged to investigate the precious material treated herein. Twenty-three tubes containing alcohol material and two boxes of 48 microscopic slides have been studied. Some of them had been rendered quite useless by desiccation, but others were in good enough condition to warrant this taxonomic work. The results of their examination follow.

The Neanurid collembola of Australia may be split into two large groups. The first of these is the *Lobellini,* in which the body tubercles do not form areolae. To this group belong *L. rosacea, newmani* and *australica.* A feature common to all these species is that the mouth parts are strongly reduced, the mandible is bi- or tricuspidate apically and the maxilla is styliform. To this group I have already given the name *Propeanura* (Yosii, 1956, p. 46). Whether this is a genus or subgenus is the matter of discussion, but I am using it as a subgenus for the moment. In all events *Propeanura* is the predominant group in the Australian continent. The second group is the *Neanurini,* in which the body tubercles are divided into areolae, more or less. With the exception of *Neanura muscorum,* whose existence in Australia might be reckoned as an introduction from Europe, there are some six further species to be included in this group. They are *N. cirrata, wellingtonia, schoetti,* cf. *novae-caledoniae, womersleyi* and *grossi.* In contrast to those of the northern hemisphere all of them are without body colour when preserved in alcohol. Their body tubercles are strongly warty in profile, especially upon the posterior body segments. Thus they would comprise a special natural group within *Neanura,* and which is nearly related to *Bilobella* in appearance. However, I could not find any fundamental difference to separate them from the coloured section of the genus. This problem must be studied in future.

1. **Lobella (Propeanura) rosacea** (Schött, 1917)

Achorutes rosaceus Schott 1917

The species was described from North Queensland. Many preparations labelled as *rosaceus* by H. Womersley are present. However they differ from the Schött's description by having an inner tooth upon the unguis. The real *rosaceus* seems to be still unrecognized. *Achorutes rosaceus* from New Hebrides (Womersley, 1937) is represented by an alcohol preserved specimen. It is not properly preserved and, although very near *L. rosaceus,* cannot be identified with certainty. *Lobella rosacea* must remain a *species inquirenda* for the moment.

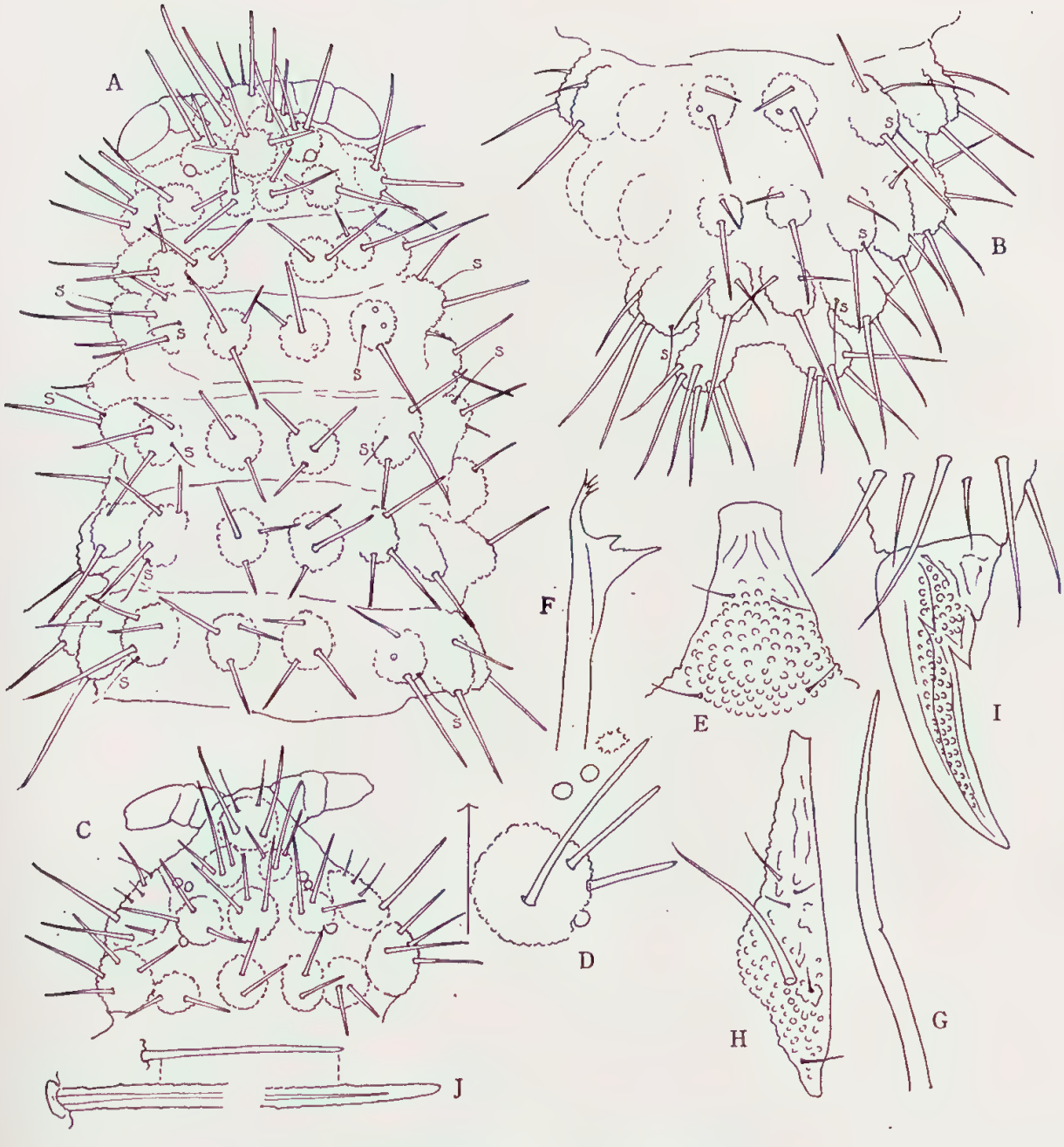
2. **Lobella (Propeanura) newmani** (Womersley 1933)

Fig. 1

Achorutes newmani Womersley 1933

Fifteen examples in alcohol and four slides labelled as cotype were seen of this large species of *Lobella.* The alcohol material seems to have been once dessicated, as the specimens are very brittle and partly shrivelled. By handling it carefully in lactic acid the following characters are observed.

Body length 3.0 mm, breadth 1.6 mm, the outline is rather elliptical. Colour dirty white, but creamy white in life (*fide* Womersley). Antennae subequal to head. Ant. IV with 3 apical bulbs and 8 well differentiated sensory setae in the usual arrangement. Ant. III-organ normal, p-, d-, v-seta all present. Buccal cone well developed. Labrum short, truncate apically and with 2 + 2 setae, the distal pair poorly developed, not much larger than the other. Mandible elongate, apically tridentate weakly and the apical tooth is divided into 3-4 minute teeth. Maxilla narrowly pointed. Labium narrow, pointed distally, all setae except one pair are small. Eyes 3 + 3, uncoloured, anterior 2 remote from ocular tubercle. Postantennal field vestigially present. Unguis with well developed dorsal side. Inner side densely granulated until near apex. Inner tooth one always present (described originally as absent). A pair of conspicuous lateral teeth are present near the basis and this character would serve as a good mark of *newmani.* Ventral tube with 4 + 4 setae. Furcal rest is a median, rounded hump upon which 5 setae (3, 1 + 1) are located. All segmental tubercles are well developed, they are hemispherical, but often mammillate upon posterior abdominal segments. Upon head all tubercles including a pair of antennal ones are present. Central tubercle bears 3 subequal setae. As shown in the figures all tubercles bear the maximum number of setae, there are small difference of length and form among them,



EXPLANATION OF FIGURES

FIG. 1

Lobella (*Propeanura*) *newmani* (Womersley), Cotype.

A, Anterior part of body; B, Posterior part of body; C, Head; D, Eyes and postantennal field; E, Labrum; F, Mandible; G, Maxilla; H, Labium; I, Mid claw; J, body seta.

which is also true of the body setae. The antennal tubercle bears 3 setae, the median (dorsal) tubercles of occipital region with 2 setae each. All the dorsal tubercles of body are well represented, th. I with 3 + 3 tubercles having 2, 2, 1 setae. Upon th. II, III there are 4 + 4 tubercles having 3, s + 3, 2, 1-2 setae. Abd. I-III with 4 + 4 tubercles having 3, 3 + s, 2, 1-2 setae. Upon abd. IV the tubercles are

elongate and with 2, 2 + s, 3, 4 setae each. Upon abd. V 2 + 2 distinct tubercles having 3, s + 3 setae. Another pair of well developed tubercles are located ventrally and can be seen from above (when the example is slightly pressed). A pair of tubercles of abd. VI are well developed, well separated and capitate in outline. The body setae are long, there are no large difference between long and short setae, they are parallel-sided, apically obtuse, and slightly rugose throughout their whole length.

L. newmani is a peculiar species by virtue of the well developed chaetal arrangement of the body. It is near *L. sauteri* Börner of Japan in the well developed tubercles of the body, but the mouth parts are quite different. Some examples from other localities of Australia and labelled as *L. newmani* proved to be different to this species. Examples from Belgrave, Victoria have smaller body setae, without the tooth upon the unguis. Those from Waterfall Gully, Belair and Fern Tree Gully are near *newmani,* but the unguis is without lateral teeth and the body setae are smooth, tapering and pointed on apex.

3. **Lobella (Propeanura) australica** sp. n.

Fig. 2

Four expls. Perth West Australia VII, 1935 K. Morris leg.
One expl. Belgrave, Victoria 19.IV.1931 H.G.A. leg.

Body long, somewhat similar to *Onychiurus* in outline. Length 2.4 mm, breadth 0.9 mm. Colour of alcohol preserved specimen dirty white. Antennae short, ant.: head as 13:20. Antennal ratio as 1:1:2. Distal segment with 3 apical bulbs and 7 curving, blunt sensory setae. p-seta present. Ant. III-organ and d-, v-seta all normal. Head with 2 + 2 large, unpigmented eyes, situated longitudinally. Post-antennal field very small, but really present. Buccal cone protruded and apically pointed. Labrum not observed. Mandible feeble, apically with an inner lobe, and the apical tooth is finely denticulated. Maxilla styliform. Unguis carinate dorsally, without inner tooth and its inner side is without structures. Ventral tube with 4 + 4 setae. Furcal rest is a median rounded area, feebly defined and with 1 + 1 setae. All body tubercles are reduced, represented by a roughly granulated area, where setae are to be found. Upon head only a median transverse area between eyes can be defined. Occipital setae in a row, without tubercles at all. From the trunk no dorsal tubercle (= area) can be defined. Th. I with 4 + 4 setae, without granulated area. Th. II, III is with 3 + 3 ant. = post. <med.) dorsal setae, subdorsal area rounded and with s + 1 setae. Sublateral area with 2 + s and lateral area with 3 setae. Upon abd. I-IV dorsal group of setae are 2 + 2 (ant. <post.), subdorsal with 1 + s, sublateral 1 and lateral 3-4

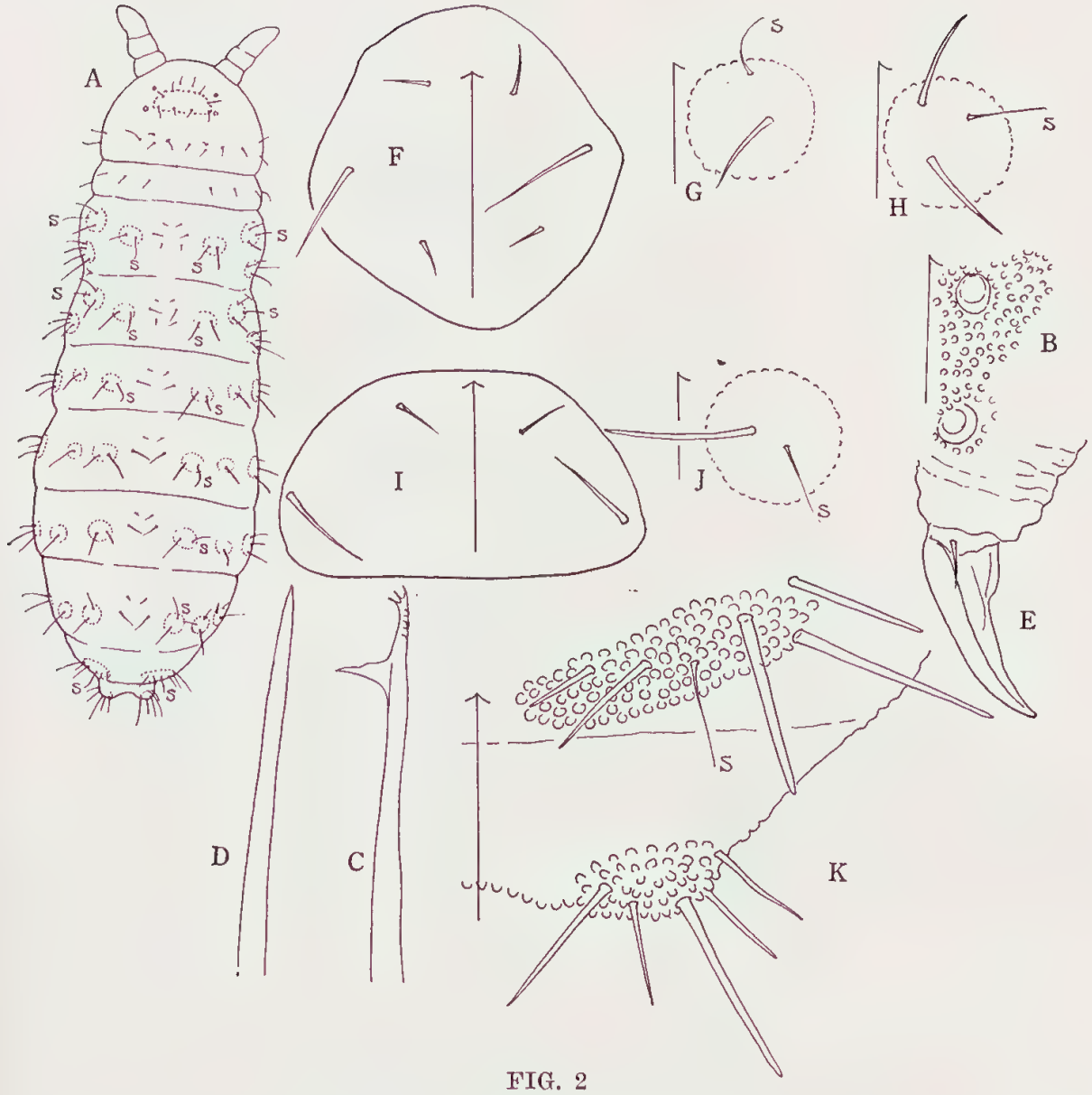


FIG. 2

Lobella (*Propeanura*) *australica* sp. n.

A, Dorsal side; B, Eyes and postantennal field; C, Mandible; D, Maxilla; E, Fore claw; F, Dorsal group of setae of th. III; G, Subdorsal tubercle of th. III; H, Sublateral tubercle of th. III; I, Dorsal group of setae of abd. III; J, Subdorsal tubercle of abd. III; K, Abd. V and VI (right half).

setae. Abd. V is very unique, dorsal and lateral tubercles are quite reduced to an oblique area postero-lateral to the segment, where 5 + s setae are located. The slender s.s. is the third seta of them. Abd. VI bears a pair of low tubercles, remote from each other. All body setae are short, uncoloured and setaceous. Larger ones are often with a sign of roughness.

The examples were labelled as *N. rosacea* Schött by Womersley.

No other *Propeamura* species with such reduced segmental tubercles are yet known. In this respect the present species is very characteristic.

4. **Neanura muscorum** (Templeton, 1835)

Achorutes muscorum Womersley 1939

Seven expls. Mount Wellington, Tasmania 9.XII.1937.

These examples have been compared with the description of Stach 1951 and with two examples of this species from Belgium. In all details they agree. Thus the species certainly occurs in Tasmania. Probably it is an introduction from Europe.

5. **Neanura** cf. **cirrata** (Schött, 1917)

Achorutes cirratus Schött 1917

Fig. 3

N. cirrata has been described from North Queensland, Schött's fig. 10 (p. 8) indicates a very peculiar feature of abd. VI, which cannot be detected in any examples of the material at hand. The exact determination must be reserved. Examples determined by Womersley as this species have the following characters. (The description is based on four examples from Glen Osmond, South Australia.)

Body length from 1.8 to 3.0 mm. Large examples are more intensely granulated and each of the granules strongly protrude from the surface, while in smaller examples with a well developed genital orifice the granulation is not so cubically produced. Body colour white in alcohol. Upon head no antennal tubercles. Frontal tubercle without a central seta. Eyes 2 + 2, unpigmented. A median pair of occipital tubercles are united in one mass medially, having 1 + 1 seta on it. Buccal cone cuspidate. Labral and labial setae as in *N. wellingtonia*. Mandible bidentate apically and slightly denticulated. Maxilla styliform. Unguis without tooth and the inner side is granulated. Furcal rest is a median, low, transverse swelling of the integument. Th. I with 1, 2, 1 setae. Th. II, III with 3, s + 3, 2 + s, —setae. Upon abd. I-III with 2, 2 + s, 3,—setae. Upon abd. IV one seta is lacking from the subdorsal tubercle (1 + s) and the s.s. is located proximal to one ordinary body seta. Upon abd. V dorsal tubercles are united in one central mass having 2 + 2 barbed setae. s.s. lies on the lateral tubercle. Abd. VI is not much produced and granulated all over. Body setae are rather short, thick and intensely barbed all over.

This species differs from *N.* cf. *novae-caledoniae* by the union of a pair of tuberculated areas of abd. VI. Womersley's *A. hirtellus*

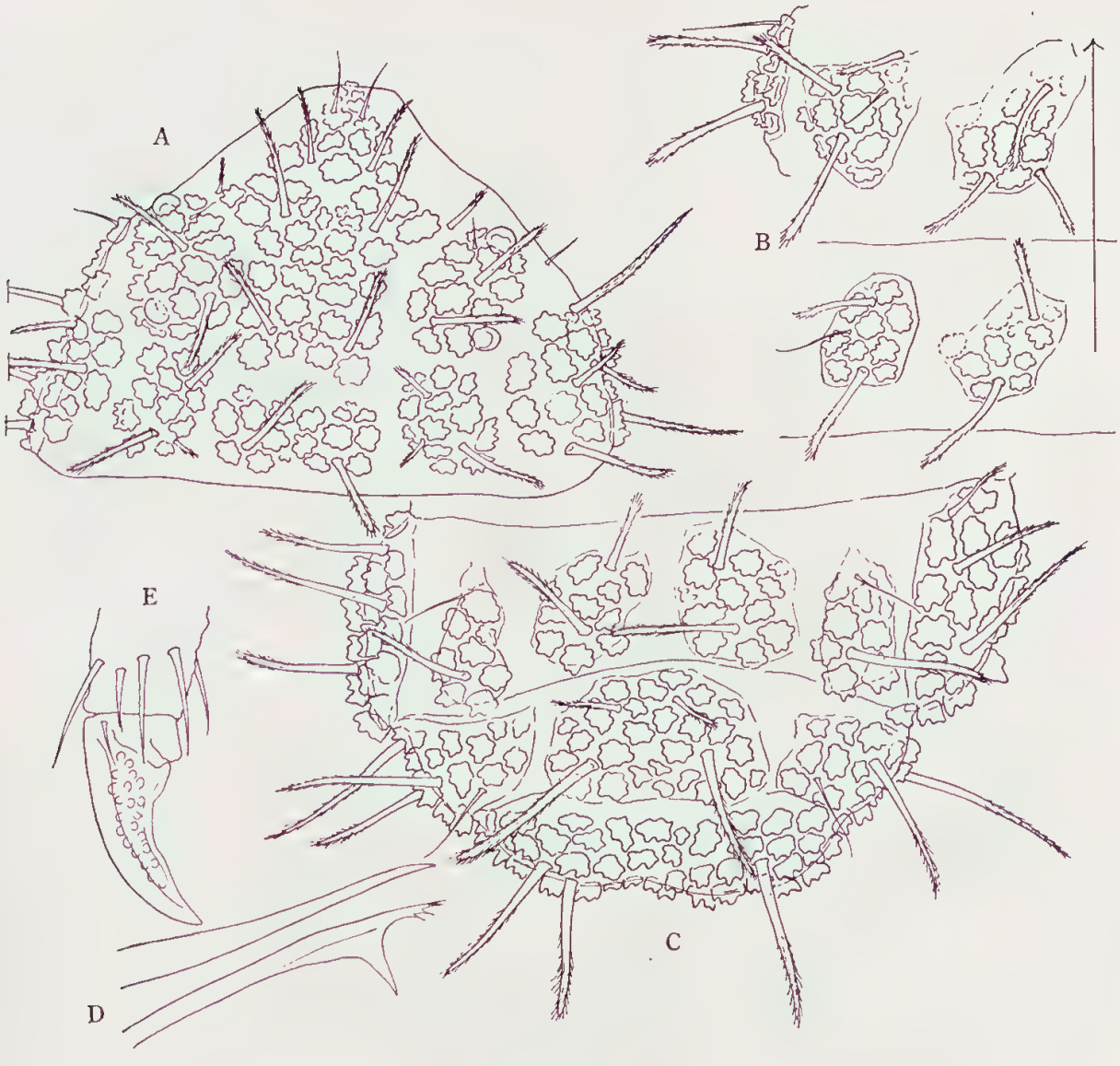


FIG. 3

Neanura cf. *cirrata* (Schött) from Belgrave, Victoria.

A, Head; B, Tubercles of th. III and abd. I (left half); C, Abd. IV, V and VI; D, Mandible and maxilla; E, Mid claw.

var. *cirratus* in 1935 (p. 209, fig. e-h) would be another independent species. In his fig. g he has shown a pair of dorsal tubercles of abd. V as widely separated to each other.

6. **Neanura** cf. **novae-caledoniae** Yosii, 1960

Four expls. Long Gully, South Australia 11.VI.1938 H. Womersley leg. Four expls. Mylor, South Australia 14.IX.1935 H. Womersley leg.

These examples are very near *N. novae-caledoniae* in the distribution of segmental tubercles and in the form of body setae. The differences are as follows. Body larger, 2.5 mm in length or more.

All body setae are larger and longer, although the serration of them and the rugose structure are not different. Compared to fig. 2, 3 of my description in 1960 the anterior margin of the frontal (= central) tubercle of head bears 4 stout setae instead of the 2 in the New Caledonian specimens. The clypeal (= apical) tubercle of the head bears 1 + 1 smooth anterior setae instead of the one median seta of the cited species. Subdorsal tubercle of the occipital row of head bears 3 setae in both lots, but one of them lying on its dorsal side is short and setaceous in New Caledonian examples, well developed and modified in the Australian examples. Upon abd. V the dorsal tubercles are united into one central mass and beset with 2 + 2 setae. In New Caledonian examples the anterior pair of setae are smooth and setaceous, while they are rugose and roughly barbed as the posterior pair in the present examples. In other details including mouth parts, form and sculpture of unguis, etc., no difference is to be detected between them.

7. **Neanura wellingtonia** Yosii sp. n.

Fig. 4

Five alcohol specimens and 2 slides from Mount Wellington, Tasmania, 1936 J. W. Evans leg. They are cotypes of Womersley's *Achorutes hirtellus* var. *wellingtonia* described in 1936.

Body length up to 4.0 mm but usually about 2.8 mm. Body colour unknown, alcoholic specimens are white. Ant.: head as 3:5. Ant. IV with 3 end bulbs apically and with 8 curving sensory setae dorsally in usual arrangement. p-seta small. Ant. III-organ is a pair of rounded rods in a groove, accompanied by blunt d- and v-seta. Ant. II and I dorsally granulated and with modified setae. Buccal cone acutely protruded. Labrum elongate, with 1 + 1 strong apical and 1 + 1 weak basal setae. Mandible slender, with 3 apical teeth. Maxilla styliform. Labium smooth, with 1 + 1, 3 + 3, 2 + 2, 4 + 4 setae, the basal one very strong. Unguis carinate, without inner tooth and its inner side is minutely granulated. Ventral tube with 4 + 4 setae. Furcal rest a median transverse tubercle with paired granulated spots. It is located near the posterior margin of abd. III, posterior to a row of 5 setae. Dorsal side of the trunk with distinctly separated segmental tubercles. Upon head the clypeal tubercle is fused with the frontal tubercle and the ocular tubercle is slightly separated from it. Eyes 2 + 2, unpigmented. Dorsal tubercle of the occipital row dorsally fused in one mass. Others as in case of *N. novae-caledoniae* Yosii. Th. I with 3 + 3 tubercles, having 1, 2, 1 setae each. Th. II, III as usual for the group, with 3, s + 3, 3 + s,—setae. Abd. I-III tubercles have 2, 2 + s, 2,—setae each. Abd. IV lacks one seta of the

FIG. 4

Neanura wellingtonia sp. n.

A, Head; B, Antennal end; C, Labrum; D, Mandible; E, Maxilla; F, Labium; G, Mid claw; H, Furcal rest; I, Body seta from dorsal tubercle of abd. I; J, Posterior part of abdomen (abd. III-VI3); K. Subdorsal tubercle of abd. IV showing the position of s.s.

subdorsal tubercle and s.s. is placed at the same level of one seta. Upon abd. V an unpaired median tubercle is placed with 2 + 2 setae, the lateral tubercle is slightly separated from it and with a weak s.s. on dorsal side. Abd. VI is broad, a paired tubercle is well separated from it and its surface is uniformly fielded and granulated all over. Body setae strong, hirsute and somewhat patellate apically.

This strikingly large species is apparently endemic to Tasmania. It is to be separated from *N.* cf. *cirrata* (Schött) and others of this group by the fusion of clypeal and frontal tubercles of the head, by the form of patellate body setae and especially by the position of s.s. upon subdorsal tubercle of abd. IV.

8. **Neanura womersleyi** sp. n.

Fig. 5

One expl. Inglewood, South Australia 23.V.1938 H. Womersley leg.

Body length 1.4 mm. Totally white in alcohol. Outline of the body rather elongate, breadth being 0.4 mm on abd. I. Ant.: head subequal in length. As the antenna is shrivelled, details are not clearly visible. Yet the terminal segment has 3 apical bulbs and many curving, blunt sensory setae. d- and v-seta are long, similar to other sensory setae. Eyes 2 + 2, unpigmented. Buccal cone protruded, labrum apically converging, with 3 + 3 setae, the most distal pair longer than others. Mandible bidentate, the apical tooth somewhat serrated. Maxilla styliform. Labium usual, the basal portion equally granulated. Unguis strongly carinate dorsally, without inner tooth and the inner side is practically smooth. Ventral tube with 3 + 3 setae. Furcal rest is a median hump with 2 + 2 setae and a small, rounded tubercle is posteriorly attached to it. Female genital field elliptical, with ca. 16 simple setae. Anal flap distinctly divided into two lobes having 10 setae each. Body tubercles very characteristic. Upon head the frontal (= central) and ocular tubercles are united in one mass, the eyes are located at the lateral margin of it. Occipital tubercles are very reduced, the dorsal pair almost imperceptible and united with the subdorsal one. Upon th. I the dorsal tubercle is absent, subdorsal one very prominent. Each with 1 seta. Upon th. II, III dorsal tubercle bears 1 + 1 large and 2 + 2 minute setae, subdorsal one with 2 + s, sublateral with 3 + s, lateral with 1 large and 2 usual setae. Upon abd. I-III dorsal tubercles are all reduced, represented by 1 large and 1 minute setae, subdorsal with 1 large, 1 small and 1 s.s. Upon abd. IV dorsal tubercle is again vestigial, subdorsal with 1 large seta and s.s. The most conspicuous character is the tubercles of abd. V, where dorsal and lateral tubercles are united in one mass, leaving a narrow median streak, which divides the tubercle of each side. s.s. is located

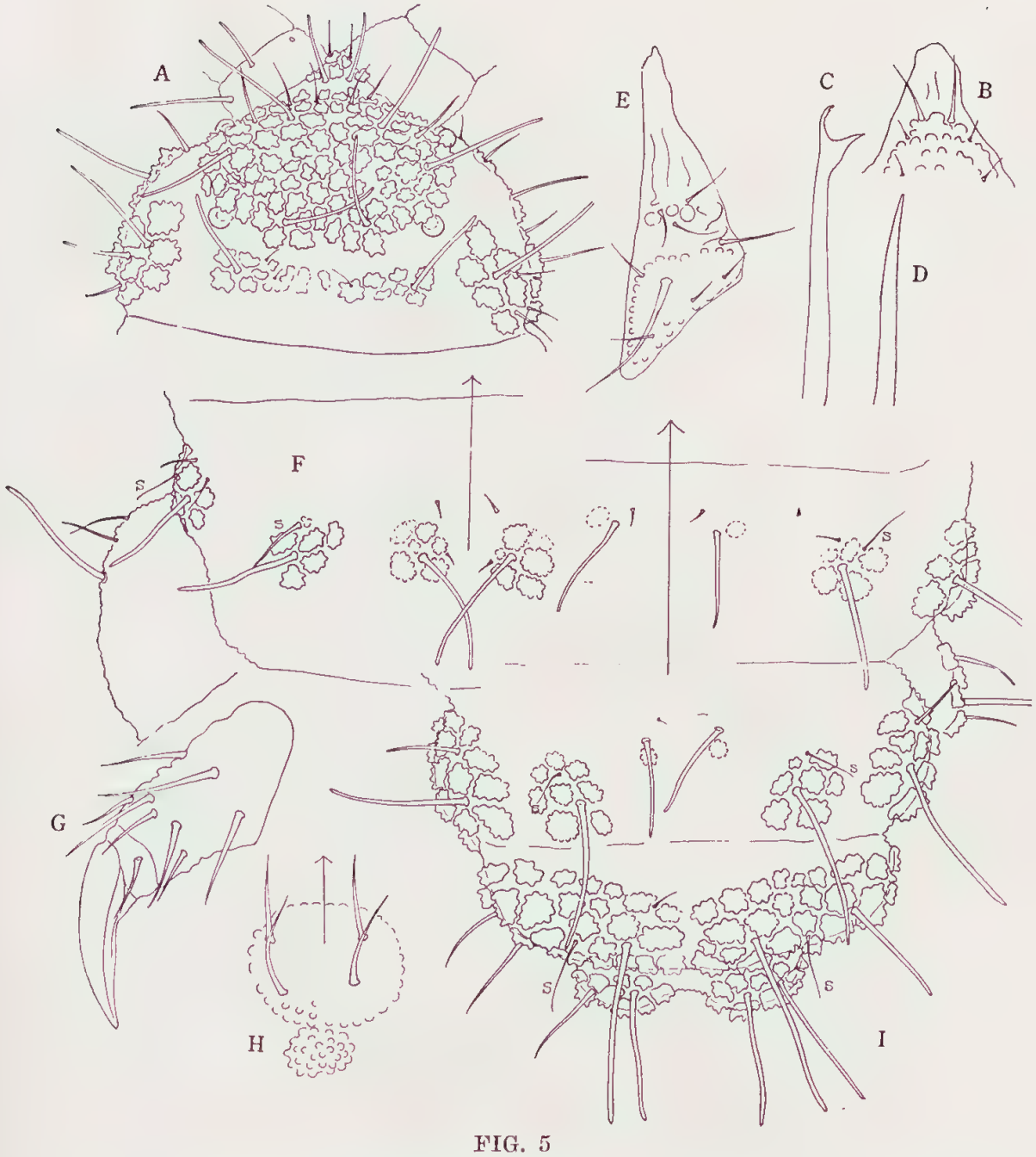


FIG. 5

Neanura womersleyi sp. n.

A, Head; B, Labrum; C, Mandible; D, Maxilla; E, Labium; F, Th. III (left half); G, Mid claw; H, Furcal rest; I, Posterior part of abdomen.

at about the middle of them. Abd. VI is half concealed by abd. V, divided by a broad median smooth area. Large body setae not converging, obtusely rounded apically and always smooth. s.s. short. All body setae uncoloured.

This species is very unique in the structure of abd. V and other features.

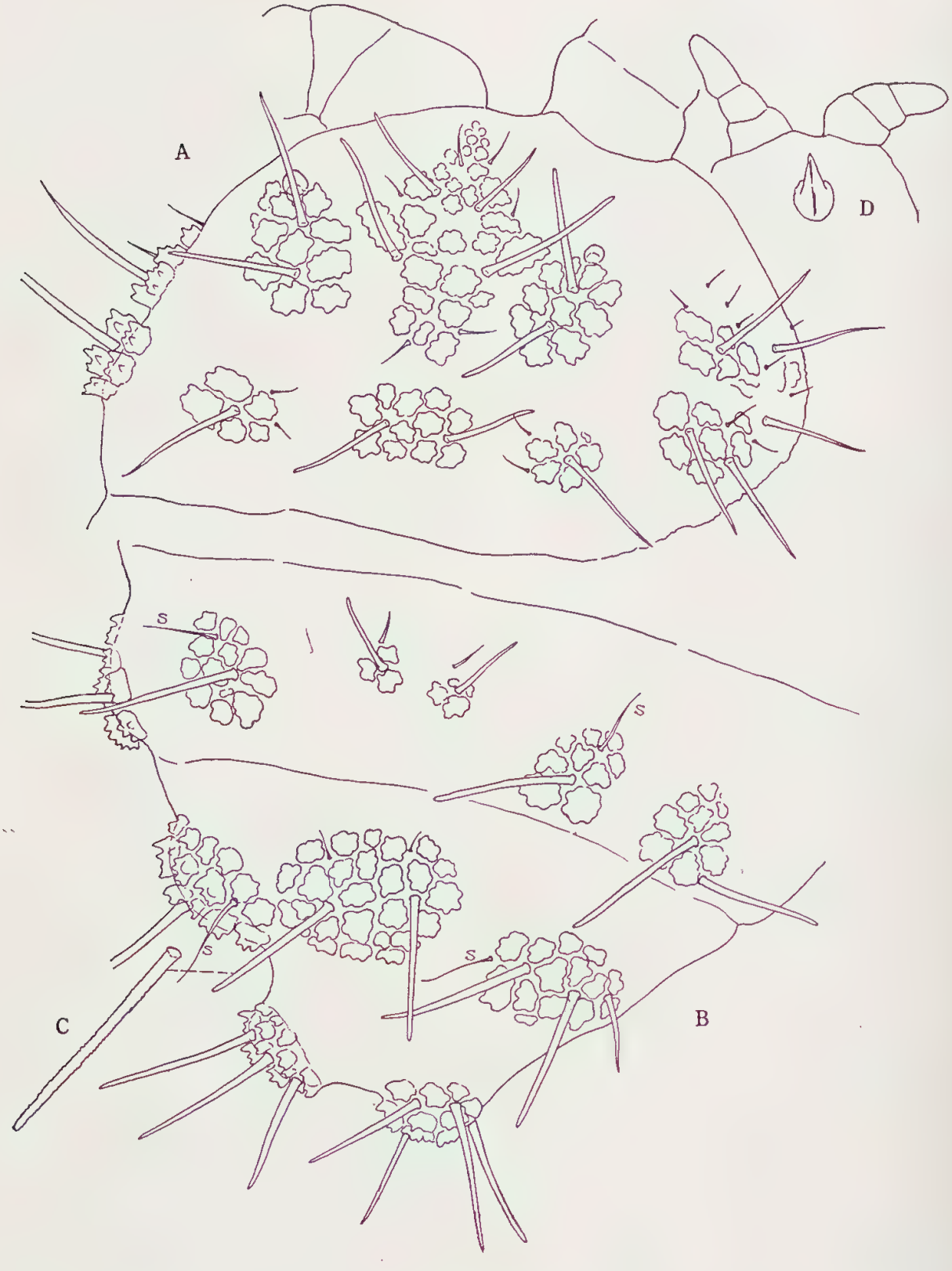


FIG. 6
Neanura grossi sp. n.
A, Head; B, Abd. IV-VI, C, Body seta; D, Buccal cone.

9. **Neanura grossi** sp. n.

Fig. 6

One expl. Bells Creek, Victoria 24.VI.1941.

Body length 1.8 mm. White in alcohol. Ant.: head as 3:5. Antennae usual in every respect for the group and sensory setae of ant. IV not coiled. Buccal cone very poorly developed, far behind the fore margin of the head. Labral and labial setae feeble, not exactly determined. Mandible feebly bidentate apically, maxilla styliform when observed by transmitted light. Unguis carinate, without inner tooth and the inner side is almost without granulation. Ventral tube with 2 + 2 (?) setae. Furcal rest absent. Body tubercles very peculiar and quite different from other species. Upon head clypeal tubercle slightly divided from the small frontal tubercle. The latter is inversely trapezoid in form, without central seta and the posterior pair of setae are small and setaceous. Ocular tubercle with 2 setae. Eyes 1 + 1, the posterior pair being absent. They are uncoloured. On the occipital region the dorsal tubercles are fused medially, having 1 + 1 setae. Th. I with 3 + 3 tubercles having 1, 2, 1 setae each. Th. II, III with 4 + 4 tubercles having 3, s + 2, 3 + s,—setae. Upon abd. I-III setae are arranged as 2, 2 + s, 2,—and upon abd. IV they are 2, 1 + s, 2,—. The dorsal tubercles of th. II- abd. IV are rather small and only one seta of them is large, others being setaceous. Upon abd. V dorsal tubercles are fused in one median large mass having 2 + 2 setae, the anterior pair of which is short and setaceous. Lateral tubercle bearing s.s. on dorsal side. Upon abd. VI a pair of tubercles are well developed and remote to each other. All larger body setae uncoloured, blunt on apex and minutely serrated.

This is a distinct species having only 1 + 1 eyes and peculiar mode of tuberculation of the trunk. It may be near cf. *cirrata* and cf. *novae-caledoniae*, but the tubercles of the head are quite different to those on either of them. In the form of body setae it is near the figure of Womersley's *Achorutes hirtellus* var. *schoetti* in 1935 (fig. 2, i), but, as stated below, we have no reliable data about this form.

Beside the species enumerated above we have two names which must be included in *Neanuridae*. They are:

1. **Achorutes hirtellus** var. **schoetti** Womersley, 1935

There are two slides determined var. *schoetti* by Womersley, one of which is from Millbrook Reservoir (type locality) and the other is from Kumara, New Zealand. The latter is nothing but *N.* cf. *cirrata* described above, while the former is a very striking new species having only one pair of tubercles upon abd. V. However, all body setae of

this example are quite smooth and as Womersley (1935, p. 209, fig. 2, i) has described the body setae of *schoetti* as minutely serrated, it would be better not to discuss the form at present.

2. **Paranura australasiae** Womersley, 1935

In all probability this is a kind of *Neanuridae* nearly related to *Lobella* (*Propeanura*) *australica* sp. n. with its reduced body tubercles.

REFERENCES

Schött, H., 1917: Results of Mr. E. Mjöberg's Swedish Scientific Expedition to Australia. Collembola, Ark. f. Zoologi 11, no. 8, 60 pp.

Stach, J., 1951: The Apterygotan Fauna of Poland, Family Bilobidae. Polska Akad. Nauk, 97 pp., 16 pls.

Womersley, H., 1935: Collembola Arthropleona of Australia, I. Poduroidea. Trans. R. Soc. S. Australia, 57: 48-71.

——— 1937: On some Apterygota from New Guinea and New Hebrides. Proc. R. entom. Soc. London B 6: 204-210.

——— 1939: *Primitive Insects of South Australia.* Adelaide, 1939, 322 pp.

Yosii, R., 1956: Monographie zur Höhlencollembolen Japans. Contr. biol. Lab. Kyoto Univ. no. 3, 109 pp. 50 pls.

——— 1960: On some Collembola of New Caledonia, New Britain and Solomon Islands. Bull. Osaka Museum Nat. Hist., 12: 9-38.

ZUSAMMENFASSUNG

Die Collembolen der Familie *Neanuridae*, gesammelt von Prof. Womersley und aufbewahrt in South Australian Museum, wurden mit neuem Gesichtspunkt untersucht. Es wurden dabei 9 Formen, unter denen 4 neuen Arten entdeckt. Alle diesen wurden mit eingehender Diagnose belegt.

ARADIDAE IN THE SOUTH AUSTRALIAN MUSEUM, ADELAIDE (HEMIPTERA-HETEROPTERA)

By NICHOLAS A. KORMILEV, Brooklyn, N.Y., U.S.A.

By the kind offices of Mr. Gordon F. Gross, Senior Curator of Invertebrates at the South Australian Museum, Adelaide, I have been privileged to study an important lot of unidentified Aradidae, mostly from Australia and Pacific Islands South of Equator, for which I wish to express my sincere gratitude to him.

Of particular interest was a batch of material collected by A. M. Lea on Fiji, Norfolk Island, Lord Howe Island, Tasmania, and Australia, amongst it many new species.

Because of the large number of species involved, this paper treats only the subfamilies: Isoderminae, Prosympiestinae, Aradinae, Calisiinae, Aneurinae, and Carventinae, the Mezirinae will be treated separately in the next paper. All measurements indicated in this paper were taken with a micrometer eyepiece, 25 units equalling 1 mm. The first figure in the ratio represents the length, and the second the width of the measured part. The length of abdomen was taken from the tip of scutellum to the tip of hypopygium (♂), or segment IX respectively (♀), only in the genus *Calisius* Stål was it taken from the fore border of connexivum II to the tip of hypopygium, or segment IX.

Fourteen of the species of Aradidae treated in this paper were found to be new; of these only five were from continental areas, the other nine were from islands. It is significant that five new species belong to the genus *Calisius* Stål, 1860, and four to the genus *Carventus* Stål, 1865.

Subfamily ISODERMINAE Stål, 1873

Gen. **Isodermus** Erichson, 1842

In Australia and Tasmania only one species is known, *Isodermus planus* Erichson, 1842. Other species have been recorded from New Zealand and South America. *Isodermus* has a curious habit of breaking off its hemelytra at the level of the tip of the scutellum, this probably occurs after copulation.

1. **Isodermus planus** Erichson

Isodermus planus Erichson, 1842, Arch. Nat.-Ges.; **8**: 280 t. 5, fig. 9.

Some of the specimens represented in this lot were very old, collected by Tepper in 1884, most of them already damaged.

1 ♂ & 1 ♀, Tasmania, Burnie—Lea coll.; 1 ♀, Tasmania, Marrawah—Lea coll.; 2 ♀, S. Australia, Meningie—H. Mincham coll.; 1 ♂, Victoria, Mt. Buffalo—F. E. Wilson coll. 21.XII.51; 1 nymph, Victoria, Beaconsfield—F. E. Wilson coll. 3.VI.18; 2 ♂ & 10 nymphs, Avenue Range—D. J. Barret coll. VIII.55; 1 ♂, Konttums Poultry Yard—1.IX.1886; 1 ♂ & 1 ♀, S. Australia, Mt. Lofty—Tepper coll. 4.XI.1884; 1 ♀, Bridgewater—Tepper coll. 2.II.1884; 1 ♂, 4 ♀ & 5 nymphs, Kangaroo Is.—G. W. Mellor coll. X.1905.

Subfamily PROSYMPIESTINAE Usinger and Matsuda, 1959

The Prosympiestinae have the same pattern of distribution as the Isoderminae, there are only four genera, of which only *Prosympiestus* Bergroth, 1894, is represented in Australia and Tasmania. Others have been recorded from New Zealand and South America.

Gen. **Prosympiestus** Bergroth, 1894

Prosympiestus has four species distributed in Australia and Tasmania, of which three were represented in this lot. *Prosympiestus* has a curious scent gland opening in the form of a pit with a stiff seta in it. Other genera of this subfamily have the normal scent gland opening similar to Isoderminae.

1. **Prosympiestus nasutus** Bergroth

Prosympiestus nasutus Bergroth, 1894, Ent. Tidskr.; 15: 117.

1 ♂, Tasmania, Waratah—Lea coll.; 1 ♂, Tasmania, Wilmot—Lea & Carter coll.

2. **Prosympiestus subparallelus** Usinger and Matsuda

Prosympiestus subparallelus Usinger & Matsuda, 1959, Class. Aradidae; p. 66, fig. 23C.

1 ♀, S.A., Adelaide.

3. **Prosympiesius constrictus** Usinger and Matsuda

Prosympiestus constrictus Usinger & Matsuda, 1959, Class. Aradidae; p. 64, fig. 23A.

2 ♂ & 1 ♀, Tasmania, Wilmot—Lea & Carter coll.; 1 ♀, N.S.W., Dorrigo—W. Heron coll.

Subfamily ARADINAE Amyot and Serville, 1843

The Aradinae contain only a single cosmopolitan genus, *Aradus* F., 1803, distributed mostly in the Northern Hemisphere (Palaearctic and Nearctic Regions).

Gen. **Aradus** Fabricius, 1803

From Australia and Tasmania only three species have been recorded to which I may add two species more, which are described elsewhere in this paper. All Australian species of *Aradus* belong to the "*lugubris* group", and are very good flyers. These species may be separated by the following key.

KEY FOR SEPARATION OF AUSTRALIAN SPECIES OF THE GENUS *ARADUS* F.

1. 2nd antennal segment depressed longitudinally 2

   2nd antennal segment rounded, not depressed 3

2. 2nd antennal segment in the middle, 3rd entirely, and 4th with exception of the tip, white; lateral borders of the pronotum irregularly denticulate . . . . . *A. albicornis* (Walker), 1873

   Antennal segments II to IV are brown, or light brown; the lateral borders of the pronotum are very finely granulate, not irregularly denticulate . . . . . *A. fuscicornis* n. sp.

3. Antennal segment IV white; lateral borders of the pronotum parallel . . . . . *A. leucotelus* (Walker), 1873

   Antennal segment IV brown or black, never white; lateral borders of the pronotum more or less convergent from the middle backward 4

4. Antennal segment II longer, longer than the distance between eyes; antennal segment III slightly depressed; antennae black, or very dark brown . . . . . *A. australis* Erichson, 1842

   Antennal segment II shorter, as long as the distance between eyes; antennal segment III rounded, tapering toward the base; antennae light brown, antennal segment II whitish in the middle, with brown base and tip . . . . . *A. erraticus* n. sp.

1. **Aradus albicornis** (Walker)

Fig. 1-2

Mezira albicornis Walker, 1873, Cat. Hem. Het. Brit. Mus., **7**: 28.
Aradus albicornis Distant, 1902, Ann. Mag. Nat. Hist., (7) **9**: 358.

2 ♂, Tasmania, Launceston; 1 ♂, Tasmania, Ulverston—Lea coll.; 1 ♀, Queensland, Emerald—Lea coll.; 2 ♂, Northern Territory, 30 m. East of Darwin—G. F. Hill coll.

2. **Aradus fuscicornis** n. sp.

Fig. 3-4

Male. Head longer than width through the eyes (♂—23:20.5, ♀—23:22). Anterior process strong, with parallel sides, rounded anteriorly, reaches to $\frac{2}{5}$ of antennal segment II. Antenniferous tubercles strong, dentiform, acute, slightly divergent, and slightly curved inward, reaching to $\frac{2}{3}$ of antennal segment I. Eyes large, globose; distance between eyes equal, or slightly larger than the length of ant. segment II (♂—12:12, ♀—13:12). Preocular tubercles distinct, acute; postocular blurred. Vertex with an "U" shaped, moderately deep depression; the white stripe behind the depression is clearly visible. Antennae less than one and a half times as long as the head (♂—29.5:23, ♀—28.5:23). Antennal segments II and III compressed; proportions, I to IV, are: ♂—3:12:7.5:7, ♀—3.5:12:7:6. Rostrum reaching middle of prosternum.

Pronotum more than half as long as its maximal width (♂—20:38, ♀—21:38). Collar with two (1 + 1) high tubercles. Anterior angles with a tooth; lateral borders firstly convex, then sinuate, and finely denticulate, on the fore lobe; parallel, and finely crenulate, on the hind lobe. Pronotal carinae subparallel, or parallel, sometimes slightly convergent backward on the hind lobe. Interlobal depression deep.

Scutellum long, triangular (♂—30:18, ♀—25:18), raised in the middle anteriorly, and transversely depressed on the elevation along basal border; deeply concave, and transversely rugose behind elevation; lateral borders reflexed, straight, or slightly convex, tip acute.

Hemelytra reaching almost to the hind border of paratergites (♂), or to $\frac{2}{3}$ of tergum VIII (♀). Corium reaches to beyond fore border of connexivum VI (♂), or to $\frac{3}{5}$ of connexivum V (♀).

Abdomen longer than maximal width across segment V (♂—54:44, ♀—60:50). Length of the abdomen is taken from the beginning of connexivum II (the first visible) to the tip of paratergites. Lateral borders convex, more so in the female. PE-angles of connexiva not protruding.

Legs slender; fore femora thicker than antennal segment II.

Colour black; PE-angles of connexiva whitish; antennae, and tibiae, light brown; basal segment of tarsi whitish, apical light brown.

Total length: ♂—4.72, ♀—4.72 mm; width of pronotum ♂—1.52, ♀—1.52 mm; width of abdomen ♂—1.76, ♀—2.00 mm.

Holotype ♂, West Australia, Mullewa—Miss F. May coll.; deposited in the South Australian Museum, Adelaide.

Allotype ♀, S. Australia, Adelaide; in the same collection.

Paratypes: ♀, S. Australia, Murray R.—F. R. Zietz coll.; 1 ♀, S. Australia, Murray R.—H. S. Cope coll.; 1 ♀, S. Australia, Lucindale—Feuerheerdt coll.; 1 ♂, S. Australia; 1 ♀, S. Australia, Klemzig—E. T. Giles coll. 14.II.56; 1 ♀, Third C[a] J. Jenning coll. 13.II.1901; 1 ♀, Queensland, Cunnamulla—H. Hardcastle coll.; 1 ♀, Queensland, Emerald—Lea coll., and 3 ♀, Kangaroo Is.

Aradus fuscicornis n. sp. belongs to "*lugubris* group", and is related to *A. albicornis* (Walker), 1873, from which it may be separated as is indicated in the key. *A. fuscicornis* n. sp. was probably often confused with *A. australis* Erichson, 1842, from which it can be separated at once by compressed antennal segment II, and lighter antennae.

3. **Aradus leucotelus** (Walker)

Fig. 5-6

Mezira leucotela Walker, 1873, Cat. Hem. Het. Brit. Mus., **7**: 28.
Aradus antennatus Distant, 1902, Ann. Mag. Nat. Hist., (7) **9**: 558.
Aradus leucotelus Kormilev, 1965, Proc. R. Soc. Queensland, **77**: 13.

1 ♀, S. Australia, Mt. Lofty; 1 ♀, N.S.W., Dorrigo—W. Heron coll.

4. **Aradus australis** Erichson

Fig. 7-10

Aradus australis Erichson, 1842, Arch. Nat. Ges., **8**: 281.

It is the commonest Australian species of the genus *Aradus* F. The shape of pronotum is rather variable: in specimens from the Australian mainland the lateral borders of the hind lobe of pronotum are only slightly convergent backward, whereas in the specimens from Tasmania this convergence is much more pronounced.

1 ♂ & 1 ♀, N.S.W., Dorrigo; 1 ♀, N.S.W., Dorrigo—W. H. Heron coll.; 1 ♂ & 3 ♀, Tasmania, Launceston 3♂ and 1 ♀ Tasmania, Launceston—Lea coll.; 1 ♀, Tasmania, Cradle Mts.—Carter and Lea coll.; 1 ♀, Tasmania, Hobart—Lea coll., and 1 ♀, Tasmania, name of locality illegible.

5. **Aradus erraticus** n. sp.

Fig. 11-12

Female. Closely related to *A. australis* Erichson, 1842, but smaller; antennae relatively shorter, antennal segment II only as long as the distance between eyes; antennal segment III rounded, tapering toward the base, where as in *A. australis* it is slightly compressed longitudinally. Corium reaches to the fore border of connexivum VI (produced over this border in *A. australis*). Other characters in both species are similar: shape of pronotum, scutellum, and abdomen. Colour also is the same, with exception of antennae, which are brown, segment II whitish in the middle (black, or very dark brown in *A. australis*).

Table of Comparative Measurements in Both Species.

	A. erraticus n. sp. ♀	*A. australis* Erich. ♀
Head	20:22	26:24
Distance between eyes	12.5	14
Proportions of ant. seg.	4:12.5:7.5:7	5:18.5:9:7.5
Pronotum	21:40	26:50
Scutellum	25:18	30:23
Abdomen	57:49	71:59
Total length	4.5 mm	5.52 mm

Holotype ♀, Queensland, Yorke Is. in the Torres Straits—C. T. McNamara coll.; deposited in the South Australian Museum, Adelaide.

Subfamily CALISIINAE Stål, 1873

Calisiinae show a curious mixture of very primitive and rather advanced characters. Among the four genera now recorded for the subfamily, *Paracalisiopsis* Kormilev, 1963, is the most primitive, *Aradacanthia* Costa, 1864, the most advanced. As primitive characters Calisiinae have:—connexivum I, which is superimposed on connexivum II as a small, triangular sclerite (in *Paracalisiopsis* it is completely developed and placed in front of connexivum II); chitinized tergum VIII in the males, which is discernible as a small sclerite in all four genera. As advanced characters should be mentioned: highly developed scutellum, covering most of hemelytra, and also the tergum up to tergum VII (in *Calisius intervenius* Bergroth, 1894, there may be observed a secundary reduction of the scutellum, which leaves tergum VI exposed); a notable reduction of corium, with corresponding reduction of venation in the membrane; a double row of granules on exterior borders of connexiva (in *Paracalisiopsis* these rows have

disappeared, and are substituted with flat teeth); moniliform first three antennal segments, and enlarged, granulate segment IV in *Calisiopsis* Champion, 1898, and *Paracalisiopsis* Kormilev.

Of the four genera *Calisius* Stål is almost circumtropical, penetrating into subtropical, and even into temperate areas in the Palaearctic. *Calisiopsis* Champion is American (Neotropical); *Aradacanthia* Costa Oriental, and *Paracalisiopsis* Kormilev is Ethiopian. In Australia only *Calisius* Stål is represented.

Gen. **Calisius** Stål, 1860

Calisius Stål has to date 45 described species, of which one is fossil from the Baltic amber; to these I can now add five more species. As all species of *Calisius* are small to very small (2.2 to 5.0 mm maximum) and as such are difficult to collect we consequently know almost nothing about their habitat. Occasionally single specimens have been found sitting on a leaf, or on a wall. Matsuda and Usinger indicate that they live in foliage and dead branches of trees.

The distribution of the 50 known species of the genus *Calisius* shows firstly, that each species is limited to a relatively small area, and secondly, that the genus as a whole is not spread over an uninterrupted area, but forms five belts, which are not in contact with each other. The first belt, in the Palaearctic, stretches along the Mediterranean sea into Central Asia (Tadjikistan). The second belt, in the Ethiopian region stretches across tropical Africa, from Senegal to Seychelles. It is separated from the first by the desert belt. The The third belt, Central American, stretches from Bahamas, and Lesser Anthilles to Central America, and Northern South America. The fourth belt, South American, stretches from S.E. Brazil to North Argentina and Bolivia. It is possible that the third and the fourth belts will be later united, but so far they are separated by the Amazon basin. The fifth belt, West Pacific, stretches from the Mariana Islands southward, across the Carolines, New Guinea, Fiji, Norfolk Island, to Australia and Tasmania. Usinger and Matsuda record *Calisius* in New Zealand, but so far no species has been described from there (1959: 44). Such a curious pattern of distribution suggests that the genus previously was distributed all around the tropics, and later started to shrink, and split in a few separate areas.

LIST OF SPECIES OF THE GENUS *CALISIUS* STÅL, 1860

I Belt—Palaearctic.

1. *Calisius balticus* Usinger, 1941, fossil, in Baltic amber.
2. *Calisius ghiliani* Costa, 1864, France, Italy, Algeria.
3. *Calisius salicis* Horvath, 1913, Yugoslavia, Syria.

4. *Calisius turanicus* Kiritshenko, 1959, Russian Central Asia (Tadjikistan).

II Belt—Ethiopian.

5. *Calisius schoutedeni* Hoberlandt, 1954, Senegal.
6. *Calisius lativentris* Horvath, 1913, Cameroun.
7. *Calisius nypelsi* Schouteden, 1919, Cameroun.
8. *Calisius horvathi* Schouteden, 1952, Congo.
9. *Calisius stappersi* Schouteden, 1919, Congo.
10. *Calisius verruciger* Horvath, 1913, Kenya.
11. *Calisius seychellensis* Kormilev, 1963, Seychelles Is.

III Belt—Central American.

12. *Calisius affinis* Barber, 1954, Bahamas Is. (Bimini).
13. *Calisius contubernalis* Bergroth, 1913—Lesser Anthilles (Guadeloupe), Florida.
14. *Calisius elegantulus* Bergroth, 1913, Guadeloupe.
15. *Calisius anaemus* Bergroth, 1913, Florida.
16. *Calisius farri* Kormilev, 1964, Jamaica.
17. *Calisius gracilis* Kormilev, 1959, Guatemala.
18. *Calisius insignis* Kormilev, 1959, Guatemala.
19. *Calisius ferox* Champion, 1898, Panama.
20. *Calisius longiventris* Kormilev, 1959, Panama.
21. *Calisius major* Bergroth, 1913, Venezuela.

IV Belt—South American.

22. *Calisius pallipes* Stål, 1860, S.E. Brazil.
23. *Calisius placidus* Horvath, 1913, S.E. Brazil.
24. *Calisius confusus* Kormilev, 1953, S.E. Brazil, North Argentina.
25. *Calisius bilobatus* Kormilev, 1959, Bolivia.

V Belt—West Pacific.

26. *Calisius saipanensis* Matsuda & Usinger, 1957, Marianas (Saipan).
27. *Calisius tinianensis* Matsuda & Usinger, 1957, Marianas (Tinian).
28. *Calisius dilaticeps* Usinger, 1946, Marianas (Guam).
29. *Calisius infuscatus* Matsuda & Usinger, 1957, Marianas (Guam).
30. *Calisius longicornis* Matsuda & Usinger, 1957, Carolines (Ponape).
31. *Calisius trukensis* Matsuda & Usinger, 1957, Carolines (Truk).
32. *Calisius acutus* Matsuda & Usinger, 1957, Carolines (Palau).
33. *Calisius araklai* Esaki & Matsuda, 1951, Carolines (Palau).
34. *Calisius micronesicus* Matsuda & Usinger, 1957, Carolines (Palau).
35. *Calisius antennalis* Horvath, 1913, N.E. New Guinea.
36. *Calisius cognatus* Horvath, 1913, N.E. New Guinea.
37. *Calisius notabilis* n. sp., N.E. New Guinea.
38. *Calisius papuanus* Horvath, 1913, N.E. New Guinea.
39. *Calisius picturatus* Horvath, 1913, N.E. New Guinea.

40. *Calisius magdalenae* n. sp., Fiji.
41. *Calisius pacificus* Kirkaldi, 1908, Fiji.
42. *Calisius leai* n. sp., Norfolk Is.
43. *Calisius australis* Kormilev, 1959, Australia (Queensland).
44. *Calisius grossi* n. sp., Australia (Queensland).
45. *Calisius hackeri* Kormilev, 1959, Australia (Queensland).
46. *Calisius intervenius* Bergroth, 1894, Australia (S. Australia).
47. *Calisius septimus* n. sp., Australia (S. Australia).
48. *Calisius annulicornis* Bergroth, 1913, Australia (Tasmania).
49. *Calisius tasmanicus* Kormilev, 1963, Tasmania.
50. *Calisius spinulosus* Blöte, 1965, Java.

KEY FOR SEPARATION OF AUSTRALIAN SPECIES OF THE GENUS *CALISIUS* STÅL

1. Anterior process of the head narrowly trapezoidal, tapering toward the base; its tip is rounded, granulate, and incised in the middle; lateral borders straight, and smooth	*C. grossi* n. sp., Queensland
Anterior process of the head obovate; its lateral borders convex, and granulate . . .	2
2. Larger species, over 4.0 mm; antennal segment III is whitish, other segments brown, or dark brown; segment III is distinctly longer than II (5.5:4)	*C. annulicornis* Bergroth, 1913. S.A., Tas.
Smaller species, less than 3.5 mm; antennal segment III is concolorous with I and II, and is as long, or only slightly longer, than II	3
3. Scutellum short, leaving tergum VI exposed in both sexes	*C. intervenius* Bergroth, 1894, S.A.
Scutellum longer always covering tergum VI	4
4. Antennal segment III subcylindrical, tapering toward the base; white band of the scutellum in the shape of two divergent hooks, united by their bases, and forming an angle; median carina of scutellum with sharp, erect granules	*C. australis* Kormilev, 1959, Qld.

	Antennal segment III ovate; white band of the scutellum in the shape of an inverted "V"; median carina of scutellum with a rounded, and somewhat blurred granulation	5
5.	Antennae robust, longer than width of the head through the eyes; white band of scutellum is clear white, very conspicuous	*C. tasmanicus* Kormilev, 1963, Tas.
	Antennae slender, and shorter, at most as long as width of the head through the eyes; white band of the scutellum yellowish, and less conspicuous	6
6.	Side strips of white band narrower; its tip placed at $\frac{1}{4}$ of scutellum's length	*C. septimus* n. sp., S.A.
	Side strips of white band wider; its tip placed more posteriorad, at $\frac{1}{3}$ of scutellum's length	*C. hackeri* Kormilev, 1959, Qsld.

1. **Calisius grossi** n. sp.

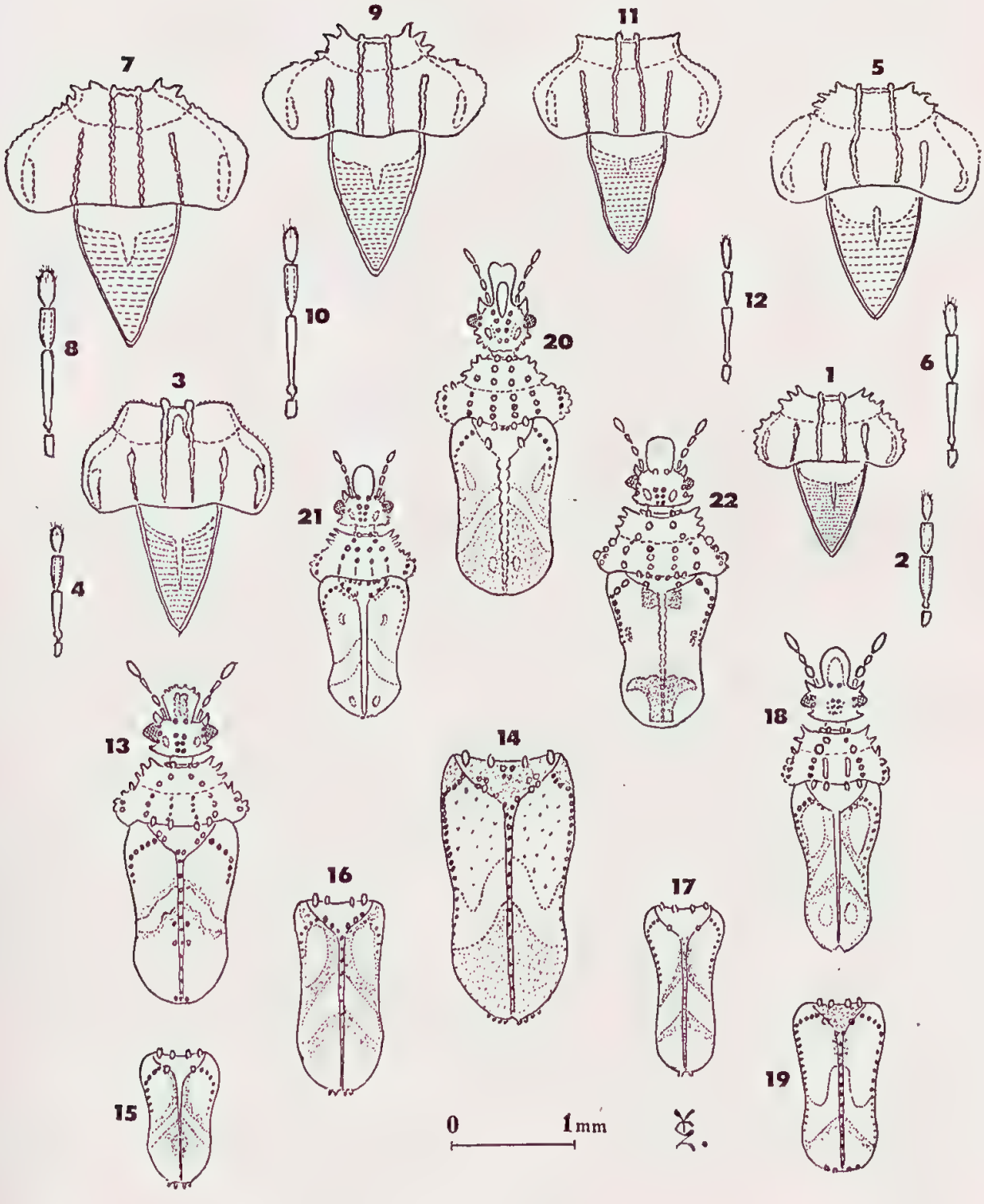
Fig. 13

Female. Elongate ovate, partially covered with erect, blunt granules.

Head as long as width through the eyes (16.5:16.5). Anterior process narrowly trapezoidal; its lateral borders straight, smooth, and convergent posteriorly; its tip rounded, granulate, and incised in the middle, reaching to the middle of antennal segment III. Antenniferous tubercles dentiform, subacute, with almost parallel outer borders, not

EXPLANATION OF DRAWINGS

Aradus albicornis (Walker), ♀, Fig. 1—pronotum and scutellum; Fig. 2—antenna.
Aradus fuscicornis n. sp., ♀, Fig. 3—pronotum and scutellum; Fig. 4—antenna.
Aradus leucotelus (Walker), ♀, Fig. 5—pronotum and scutellum; Fig. 6—antenna.
Aradus australis Erichson, ♀ from N.S.W., Fig. 7—pronotum and scutellum; Fig. 8—antenna; ♀ from Tasmania (other extreme), Fig. 9—pronotum and scutellum; Fig. 10—antenna.
Aradus erraticus n. sp., ♀, Fig. 11—pronotum and scutellum; Fig. 12—antenna.
Calisius grossi n. sp., ♀, Fig. 13—head, pronotum and scutellum.
Calisius annulicornis Bergroth, ♀, Fig. 14—scutellum.
Calisius intervenius Bergroth, ♀, Fig. 15—scutellum.
Calisius tasmanicus Kormilev, ♂, Fig. 16—scutellum.
Calisius hackeri Kormilev, ♀, Fig. 17—scutellum.
Calisius septimus n. sp., ♀, Fig. 18—head, pronotum and scutellum.
Calisius australis Kormilev, ♀, Fig. 19—scutellum.
Calisius magdalenae n. sp., ♂, Fig. 20—head, pronotum and scutellum.
Calisius leai n. sp., ♂, Fig. 21—head, pronotum and scutellum.
Calisius notabilis n. sp., ♀, Fig. 22—head, pronotum and scutellum.



Figs. 1-22.

quite reaching to the tip of antennal segment I. Eyes protruding, reniform, but not pedunculate. Postocular tubercles formed by a small granule, not attaining the outer borders of the eyes by a considerable amount. Vertex with a blunt, "V"-form granulation. Antennae slender, longer than width of the head through the eyes (19.5:16.5); segments I and II ovate, III more slender, and tapering toward the base, IV fusiform; proportions, I to IV, are: 3:3:3.5:5.

Pronotum half as long as its maximal width (15:29). Fore lobe with four (2 + 2) parallel, blunt tubercles, and in addition two (1 + 1) smaller ones somewhat laterally placed to the former, and near the hind border of fore lobe. Lateral borders of fore lobe with a few long, blunt spicules, directed sideways. Hind lobe much wider and higher than fore lobe, with six (3 + 3) rows of smaller, blunt tubercles; the disc between them is finely punctured.

Scutellum large, long, and wide (36:22) reaching almost to hind border of tergum VI; basal elevation relatively small, and high, with four (2 + 2) rows of tubercles: each outer row made up of one large tubercle, each inner row made up of two somewhat smaller tubercles. Median carina high, and granulate; with a small cluster of granules at the base, and a single row (intermittently) of more elevated then lower granules more posteriorly. At the base of scutellum laterally run two (1 + 1) arcuate, dense rows of smaller tubercles, reaching to ¼ of scutellum's length. Along the middle portion of median carina are located on both sides a few smaller, and more distant, tubercles. Disc roughly and densely punctured.

Hemelytra are visible only as a row of dense, blunt granules.

Abdomen longer than width across segment IV (43:34). In this, and the following species of the genus *Calisius,* the length of abdomen is taken from fore border of connexivum I to the tip of abdomen. Connexivum wide and reflexed; connexiva are wider than their length; outer borders of connexiva with a double row of blunt tubercles; each connexivum from II to VII bears in each row two smaller, dark tubercles, and one larger whitish one. Connexivum I is small, triangular, superimposed on connexivum II. Tergum VII (♀) in a form of an inverted trapezoid. Segment IX is long, much longer than small paratergites. Spiracles from II to VI are ventral, and not visible from above; VII lateral, placed on a large tubercle, and VIII terminal.

Colour: pale testaceous; scutellum on the hind half mottled with creamy-yellow; inverted "V" band is also creamy-yellow, and somewhat blurred.

Total length, 3.12 mm; width of pronotum, 1.16 mm; width of abdomen, 1.36 mm.

Holotype: ♀, Australia, Queensland, Cairns district—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

It is a pleasure to dedicate this species to Mr. Gordon F. Gross, Senior Curator of Invertebrates in the South Australian Museum, by whose kind offices I have been privileged to study this important, and interesting, lot of Aradidae in his charge.

Calisius grossi n. sp. is very different from all Australian species of *Calisius*, and may be separated from them at once by the shape of anterior process of the head, and colour; its antennae somewhat resemble those of *C. australis* Kormilev, 1959, but the shape of the body, head, and colour, are quite different.

2. **Calisius annulicornis** Bergroth

Fig. 14

Calisius annulicornis Bergroth, 1913, The Can. Ent., **45**: 9.

1 ♂, South Australia, Lucindale—Feuerheerdt coll.

3. **Calisius intervenius** Bergroth

Fig. 15

Calisius intervenius Bergroth, 1894, Ent. Tidskr., **15**: 97.

1 ♂ & 5 ♀, South Australia, Mt. Lofty Rgs.; 1 ♂ & 2 ♀, S.A., Mt. Lofty Rgs.—S. H. Curnow coll.; 1 ♂ & 1 ♀, S.A., Mt. Lofty—Tepper coll. 14.VII.1884; 4 ♂, S.A., Mt. Lofty, Second Creek—Tepper coll. 4.XI.1884; 1 ♂ & 1 ♀, S.A., Second Creek—Tepper coll. 9.X.1886; 2 ♂ & 2 ♀, Magill—Tepper coll. 7.VII.1884; 2 ♂, S.A., Mt. Lofty—Tepper coll. 11.IX.1887; 1 ♂ & 2 ♀, Mt. Torrens—Oct. 1916; 1 ♂ & 1 ♀, Victor Harbour—H. Womersley coll. Jan. 1934; 1 ♀, S.A., Lucindale—Feuerhardt coll.; 2 ♂ & 1 ♀, Clarendon (under bark of *Eucalyptus*); 1 ♀, S.A., Kangaroo Is.—A. M. Lea coll.

4. **Calisius tasmanicus** Kormilev

Fig. 16

Calisius tasmanicus Kormilev, 1963 (1962), Ann. Mag. Nat. Hist.; Ser. 13, **5**: 604, figs. 3-5.

2 ♂, Tasmania, Hobart—A. M. Lea coll.; 1 ♂, Tasmania, Huon R.—A. M. Lea coll.; 2 ♂, Tasmania—A. Simson coll.; 1 ♂, St. Marys.

5. **Calisius hackeri** Kormilev

Fig. 17

Calisius hackeri Kormilev, 1959 (1958), Proc. U.S. Nat. Mus.; **109** (No. 3413): 219, fig. 13-14.

1 ♂, Australia—Blackb's coll.; 2 ♂, Flinders Range—E. L. Savage coll.; 2 ♀, Mt. Serle, N. Flinders Range—Hale & Tindale coll.; 2 ♂, S.A., Quorn.

6. **Calisius septimus** n. sp.

Fig. 18

Female. Elongate ovate; closely related to *C. hackeri* Kormilev, 1959, from which it may be separated as is indicated in the key. In other characters, and colour, they are pretty similar.

Measurements: head almost as long as width through the eyes (15:14); proportions of antennal segments, I to IV, are 2.5:3:3:5.5; pronotum half as long as its maximal width (12:23); scutellum much longer than its maximal width (33:18); abdomen longer than its maximal width (40:26).

Total length, 3.0 mm; width of pronotum, 0.92 mm; width of abdomen, 1.04 mm.

Holotype: ♀, South Australia, Pt. Lincoln—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Paratype: 1 ♀, Clarendon—Tepper coll. 19.IV.1884; in the collection of the author.

7. **Calisius magdalenae** n. sp.

Fig. 20

Male. Elongate ovate, partly covered with rough, blunt granules.

Head longer than width through the eyes (♂—17.5:15.5, ♀—17.5:16). Anterior process long, with parallel sides, anteriorly flattened, and incised in the middle of fore border, reaching almost to the tip of antennal segment III. Antenniferous tubercles dentiform, acute, divergent, reaching almost to the tip of antennal segment I. Eyes, small, semiglobose, very protruding, but not pedunculate. Postocular tubercles consist of 2 or 3 small granules, not reaching to the outer border of the eyes by quite a large amount. Vertex with "V"-shape rough granulation. Antennae short, and slender, slightly shorter than width of the head through the eyes (♂—14.5:15.5, ♀—15:16); first two segments subcylindrical, 3rd tapering toward the base, 4th fusiform; proportions of the antennal segments, I to IV, are: ♂—2.75:2.75:3.75:5, ♀—2.75:2.75:4:5.5. Rostrum short, does not reach to the base of rostral groove.

Pronotum half as long as maximal width (♂—14:29, ♀—15:31). Collar distinct, with two (1 + 1) small granules on upper side. Fore lobe convex, with two transverse rows of rough granules: two (1 + 1) in the front row, and four (2 + 2) in the hind row. Lateral borders provided with 3 or 2 rough, blunt spicules. Interlobal depression

narrow and deep. Hind lobe much wider, and higher than fore lobe, provided with six (3 + 3) longitudinal rows of granules, divergent backward: four rows on the disc, and two along the humeri.

Scutellum longer than its maximal width (♂—34:22, ♀—39:22). Lateral borders slightly sinuate in the middle; hind border subtruncate. Basal, triangular elevation is rather small, but high; provided with four (2 + 2) rough granules, placed along basal border, and slightly overlapping the hind border of pronotum. Median carina is high, and thick at the base, but rapidly tapering, and becoming lower toward the tip; granulation of carina is blunt, dense, and low. Two (1 + 1) arcuate rows of granules near the base are fine, and rather short, gradually disappearing behind the level of connexivum I. Lateral borders of hind half, and the tip of scutellum, are carinate, but without granules. Disc roughly punctured, particularly rough on the hind half.

Hemelytra seen as narrow carinae, with blurred granulation; corium reaches to connexivum IV.

Abdomen longer than its maximal width (♂—42:33, ♀—44:39). Connexivum wide, and slightly reflexed; connexiva wider than their length. Lateral borders with a double row of rough, blunt granules, particularly rough in the female; each connexivum has two granules (one black, and one white) in the upper row, and three granules (two black, and one white) in the lower row. Tergum VII in the male is raised in the middle for reception of hypopygium; tergum VIII in the male is seen as a narrow border behind, and a little below tergum VII. Hypopygium is ventro-caudal in position; paratergites small and blunt. Tergum VII in the female is flat, and rather smooth, with small granules along the fore, and hind, borders; paratergites bicuspidate, short; segment IX long, and narrow, tricuspidate at the tip. Spiracles ventral from II to VI; lateral, placed on granule on VII; terminal on VIII.

Colour: dark reddish brown to black; clypeus, and vertex, with pinkish tinge; scutellum with two (1 + 1), anteriorly contiguous, "S"-shaped, whitish spots, forming a kind of an inverted "U"; in the antero-lateral angles of scutellum two (1 + 1) elongate, whitish spots, and near the tip, along median carina, two (1 + 1) more, small, whitish spots. Connexivum I whitish. Antennae greyish brown, progressively becoming lighter toward the tip; ant. segment IV is pale brown to whitish. Legs ochraceous; bases of femora brown.

Total length: ♂—3.2, ♀—3.4 mm; width of pronotum: ♂—1.16, ♀—1.24 mm; width of abdomen: ♂—1.32, ♀—1.56 mm.

Holotype: ♂, Fiji, Savu Savu, Vanua Levu—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Allotype: ♀, collected with the holotype; in the same Museum.

Paratypes: 2 ♂, collected with the holo, and allotype; in the same collection, and collection of the author.

It is a pleasure to dedicate this striking species to my wife, Mrs. Magdalena Kormilev, as a sign of my gratitude to her constant help in my entomological work.

Calisius magdalenae n. sp. is related to *C. tinianensis* Matsuda & Usinger, 1957, from Tinian, Mariana Is. from which it differs by anteriorly more dilated, and flattened anterior process of the head; different proportions of antennal segments, and larger size.

8. **Calisius leai** n. sp.

Fig. 21

Male. Elongate ovate, rather convex; partially finely granulate.

Head as long as width through the eyes (12.5:12.5). Anterior process robust, high, with slightly convex sides, its tip is rounded, reaching slightly over the tip of antennal segment II. Antenniferous tubercles small, dentiform, acute, their outer borders parallel; reaching almost to the tip of antennal segment I. Eyes moderately large, semiglobose, protruding. Postocular tubercles consist of a few very small, whitish granules, reaching or almost reaching to the outer border of the eyes. Vertex with "V"-shaped granulation, and laterad of it two (1 + 1) rows of smaller granules. Antennae short, and very slender, shorter than the head's width through the eyes (11.5:12.5). Antennal segment I subcylindrical, II and III tapering toward the base, IV fusiform. Proportions, I to IV, are: 2.5:2.5:2.5:4. Rostrum reaching to the hind border of rostral groove.

Pronotum half as long as its maximal width (10:21), and strongly declivous forward. Interlobal depression narrow, and shallow. Collar with two (1 + 1) erect, small granules. Fore lobe with two (1 + 1) granules placed behind those of the collar, and two more, more widely apart, placed near hind border. Lateral borders each with three inclined spicules. Hind lobe is wider and higher than fore lobe, provided with six (3 + 3) rows of granules: the inner ones have two (1 + 1) erect granules near fore border, and behind them very thin, and low, finely granulate carinae. Middle rows have six (3 + 3) small granules, and outer rows, running along humeri, have four (2 + 2) larger granules, disc between granules is very finely punctured.

Scutellum is longer than its maximal width (28:17); its lateral borders sinuate at the middle, apical border rounded. Basal, triangular elevation is small, and moderately high; at its foreborder are placed

eight small granules; in the middle of lateral borders are placed two (1 + 1) granules more. Median carina is thin, and high, finely granulate. Laterad of the basal elevation are placed two (1 + 1) arcuate rows of fine granules, reaching laterally a little over connexivum I; further backward lateral borders of the scutellum are carinate, but without granulation. Disc densely, and moderately rough punctured.

Hemelytra are seen as carinae, reaching to the hind border of connexivum IV.

Abdomen longer than its maximal width (28:23.5); connexivum narrow (connexiva are longer than their width); lateral borders with a double row of very fine granules, three on each connexivum; these granules are almost evanescent in the lower row. Connexivum I in the shape of a whitish triangle, superimposed on connexivum II. On connexivum VII granules are larger than on II to VI. Tergum VIII very short, with four (2 + 2) small granules at the hind border. Hypopygium small, ventro-caudal in position. Spiracles very small, II to VI ventral; VII placed on tubercles, VIII lateral.

Colour: brown to dark brown; granulations on vertex, basal row on the scutellum, and connexivum VII, are whitish; inverted "V" band of the scutellum is also whitish. Four spots (2 + 2) in front, and behind inverted "V"-band, light brown. Antennal segment I to III are brown, IV piceous; femora piceous with whitish tips; tibiae, and tarsi whitish.

Total length, 2.28 mm; width of pronotum, 0.84 mm; width of abdomen, 0.94 mm.

Holotype: ♂, South Pacific, Norfolk Is.—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

This species is dedicated to Mr. A. M. Lea, who was an excellent collector, and collected many species on Fiji, South Pacific Islands, Tasmania, and Australia.

Calisius leai n. sp. is somewhat related to *C. acutus* Matsuda & Usinger, 1957, from which it differs by: different proportions of the antennal segment; by a very narrow connexivum; by an almost evanescent granulation in the lower row on the borders of the connexivum and by a different colour.

9. **Calisius notabilis** n. sp.

Fig. 22

Female. Elongate ovate; upper surface covered with a very thin, white incrustation.

Head slightly longer than width through the eyes (15:13.5).

Anterior process robust, obovate, rounded anteriorly, and slightly convex laterally, reaching to the middle of antennal segment III. Antenniferous tubercles tiny, acute, slightly divergent, not quite reaching the tip of antennal segment I. Eyes large, subconical, protruding. Postocular tubercles tiny, dentiform, do not reach to the outer border of the eyes; behind, and mesad, of them are placed four (2 + 2) small granules. Vertex with two (1 + 1) contiguous rows of tubercles, three in each row. Antennae slender, and short, distinctly shorter than the head (12:15). Antennal segment I subcylindrical, II ovate, III tapering toward the base, IV fusiform; proportions, I to IV, are: 2:2.5:2.5:5. Rostrum reaches to the base of the head.

Pronotum rather flat; half as long as its maximal width (12.5:25). Collar high, distinctly separated from the disc by a thin, and deep sulcus, and provided with two (1 + 1) larger granules. Lateral borders of the fore lobe with six (3 + 3) larger, blunt spicules, which are larger than granules on the hind lobe. Fore disc with four (2 + 2) granules: two (1 + 1) of them placed behind those of the collar, and two (1 + 1) more laterad, and more backward of them. Hind disc with six (3 + 3) rows of three granules each; the inner rows are parallel; the middle ones slightly convex exteriorly, and the outer ones run across humeri.

Scutellum much longer than its maximal width (32:20). Six (3 + 3) granules placed along basal border, of which the inner ones are smaller; two (1 + 1) granules more are placed at lateral borders. Basal, triangular elevation is small, moderately high; median carina thin, relatively low, granulate; lateral, arcuate rows (1 + 1) of progressively diminishing granules reach laterally to the middle of connexivum V. Disc finely punctured.

Hemelytra with corium reaching to hind border of connexivum IV.

Abdomen longer than its maximal width across segment IV (36:29). Connexivum moderately reflexed; exterior borders of connexiva with a double row of granules, which are as large as those on the hind disc of pronotum. Spiracles ventral from II to VI; lateral, placed on a small tubercle, on VII; lateral on VIII. Paratergites small, each bearing two granules; segment IX narrow, moderately long, very slightly incised at the tip.

Colour: pale greyish-ochraceous; eyes black. Black spots: two (1 + 1) transverse spots along border of pronotum, between inner and middle rows of granules; triangular elevation of scutellum (the black colour is concealed by white incrustation, and looks grey); two (1 + 1) quadrangular spots at the base of the median carina of scutellum; two (1 + 1) small streaks at the middle of the lateral

borders of scutellum; two (1 + 1) larger spots in the shape of an inverted "L", together forming a "T"-shaped large spot at the tip of scutellum. Basal half of connexivum II, and the middle granule in the upper row of connexia III to VII; one median spot at the hind border of tergum VII; the middle of tergum VIII, and the base of segment IX, are also all black. Antennae, legs, and the ventral side of the body greyish-ochraceous.

Total length, 2.8 mm; width of pronotum, 1.0 mm; width of abdomen, 1.16 mm.

Holotype: ♀, New Guinea, Finsch Haven—Rev. L. Wagner coll.; deposited in the South Australian Museum, Adelaide.

Calisius notabilis n. sp. is related to *C. cognatus* Horvath, 1913, also from New Guinea, and may be separated from the latter by different proportions of antennal segments (segment IV is twice as long as III, as long as II and III together), and by a different pattern of black spots on the scutellum.

Subfamily ANEURINAE Douglas and Scott, 1865

There are only two genera of Aneurinae: *Aneurus* Curtis, 1825, a cosmopolitan genus, and *Aneuraptera* Usinger and Matsuda, 1959, with a single, micropterous species from New Zealand.

Gen. **Aneurus** Curtis, 1825

Five species have been recorded from Australia. The species may be separated by the following key:—

KEY TO AUSTRALIAN SPECIES OF THE GENUS *ANEURIS* CURTIS

1. PE-angles of connexiva II to VI distinctly produced, forming an angle . . . . . *A. angulatus* Kormilev 1965

   PE-angles of connexiva not produced 2

2. Antennal segment III subcylindrical 3

   Antennal segment III regularly tapering toward the base 4

3. Antennal segment III more than twice as long as II; terga IV and V in the male provided with small tubercles, absent in the female . . . . . *A. androphymus* Bergroth, 1914

   Antennal segment III subequal in length to II; male without tubercles on terga IV and V . . . . . *A. robustus* Kormilev, 1957

4. Antennal segment III distinctly longer than II (4:3); larger species, over 5 mm .. .. *A. australicus* Stål, 1873

Antennal segment III as long as II; smaller species, 4 mm or less, exceptionally females may reach 5 mm .. .. *A. crenulatus* Kormilev, 1957

1. **Aneurus australicus** Stål

Aneurus australicus Stål, 1873, Enum. Hemipt., **3**: 146.

2 ♀, South Australia, Lucindale—Feuerheerdt coll.; 1 ♂, S.A., Lucindale—F. Secker coll.; all three specimens are mutilated.

2. **Aneurus crenulatus** Kormilev

Aneurus crenulatus Kormilev, 1957, Quarterly Jour. Taiwan Museum, **10**: 45.

2 ♂, New South Wales, Sydney—Lea coll.; 1 ♀, S.A., Lucindale—Feuerheerdt coll., the latter is abnormally large, 5 mm, whereas normally females of this species are about 4 mm long.

3. **Aneurus robustus** Kormilev

Aneurus robustus Kormilev, 1957, Quarterly Jour. Taiwan Museum, **10**: 44.

This is the commonest species in Eastern Australia, particularly in Queensland and New South Wales.

4 ♂, New South Wales, Dorrigo—W. Heron coll.; 7 ♂, 2 ♀, & 5 nymphs, N.S.W., Upper Williams R.—Lea & Wilson coll. X.1926; 2 ♂ & 5 ♀, Queensland, Mt. Tambourine—A. M. Lea coll.; 2 ♀, Kuranda—F. P. Dodd coll.

4. **Aneurus micronesicus** Esaki and Matsuda

Aneurus micronesicus Esaki and Matsuda, 1951; Mushi, **22**: 83.

Described from Caroline Islands, now recorded from Papua.

3 ♂, New Guinea, N.E. Papua, Mt. Lamington, 1,300-1,500ft.—C. T. McNamara coll.

5. **Aneurus cetratus** Bergroth

Aneurus cetratus Bergroth, 1894, Ann. Mus. St. Nat., Genova, **34**: 112.

Described from New Guinea, later recorded from the Philippine Islands, Sumatra, and Java; and here recorded from the Malay Peninsula.

2 ♂, Malaysia, Malay Peninsula, Gap, Fraser's Hill—A. M. Lea & wife coll.

Subfamily CARVENTINAE Usinger, 1950

Gen. **Carventus** Stål, 1865

The genus *Carventus* Stål also has a very wide range of distribution: from Burma, across Indonesia, and New Guinea, to Australia, then again in the Pacific Islands (Samoa). One species occurs in Central America (Mexico), and a few species in tropical Africa, and Madagascar. Ethiopian, and Malagasian species previously were placed in the genus *Burgeonia* Schouteden, 1919; later this genus was synonymized with *Carventus* Stål, by Usinger and Matsuda (1959: 118). The genus *Camerarius* Distant, 1902 also was synonymized with *Carventus* by the same authors (1959: 120), though both these genera could perhaps be retained as subgenera, as they have been treated by this author, but it is difficult to say without a thorough revision. It is interesting to note, that half of all species of the genus *Carventus* Stål, recorded from the Oriental Region and the Pacific Islands, come from New Guinea and adjacent islands.

1. **Carventus malayensis** n. sp.

Fig. 23

Female. Elongate ovate, covered with brownish incrustation.

Head as long as width through the eyes (22.5:22.5), but shorter than width across postocular tubercles (22.5:26). Anterior process strong, slightly constricted in the middle, and incised in front, reaches to $\frac{3}{4}$ of antennal segment I. Antenniferous tubercles strong, dentiform, acute, divaricating, provided with a small tubercle on exterior border near the base, reaching to $\frac{1}{3}$ of antennal segment I. Eyes moderately large, protruding. Postocular tubercles dentiform, adjacent to the eyes, produced far beyond the outer border of the eyes. Vertex with a high, granulate, median carina, and two (1 + 1) lower, and thinner, smooth carinae laterad of the median. Postocular borders carinate, and sinuate, terminating with a tubercle directed backward. Antennae are one and a half times as long as the head (37:22.5); antennal segment I clavate; II and III tapering toward the base; IV elongate fusiform. Proportions, I to IV, are: 10.5:7:10:9.5. Rostrum reaches to the hind border of rostral groove.

Pronotum shorter than width across the humeri (27:47), distinctly divided into two lobes by a deep, and wide, depression. Collar clearly separated from the disc. Just behind the collar is placed a crescent-shaped, transverse ridge; and behind the latter a short, thin median sulcus, terminated with a tubercle placed in the interlobal depression. Antero-lateral angles produced as lobes, rounded anteriorly, and laterally, separated from the collar by a deep incisure. Along the fore

border of the lobes runs a granulated ridge, and another one, crescent-shaped, is placed behind the latter, and along the lateral border of fore lobe. Lateral borders twice, deeply sinuate, and with a strong tooth between them. Hind lobe much wider than the fore lobe (47:38), raised at humeri, and declivous anteriorly; along the hind border runs a fine, transverse sulcus. Lateral borders of hind lobe strongly convex, and with a tubercle in the middle. Hind border straight in the middle, angularly produced laterad of scutellum (hind angles).

Scutellum subtriangular, shorter than width at the base (15:26). Lateral borders convex; tip angularly rounded; disc transversely raised at the base, and with a low median carina behind basal elevation.

Hemelytra reach to $\frac{1}{3}$ of tergum VII; corium reaches a little over the middle of scutellum; its exterior border is carinate, convex.

Abdomen ovate, longer than maximal width across segment IV (75:63). Connexivum wide and flat. Connexiva II and III semifused, others clearly separated from each other. PE-angles II to VI barely protruding; PE-VII form an obtuse angle. Posterior border of tergum VII, and connexiva VII form together a barely sinuate line. Paratergites strong, conical, reach to $\frac{3}{5}$ of segment IX; the latter truncate posteriorly. Spiracles II to VIII lateral, and visible from above.

Legs: unarmed.

Colour: dark reddish-brown; connexivum, tibiae, and tarsi, yellow brown.

Total length, 5.84 mm; width of pronotum, 1.88 mm; width of abdomen, 2.52 mm.

Holotype: ♀, Malaysia, Malay Peninsula, Gap (Fraser's Hill)—A. M. Lea & wife coll.; deposited in the South Australian Museum, Adelaide.

Carventus malayensis n. sp. is related to *C. gestroi* Bergroth, 1892, from Burma, but differs from it by: larger size; antero-lateral angles of the pronotum rounded anteriorly and laterally, not obliquely truncate, and by different proportions of antennal segments.

2. **Carventus ovatus** n. sp.

Fig. 24

Male. Ovate, regularly tapering from the middle of abdomen forward, and less so backward; more or less covered with a greyish incrustation, with exception of antennae, legs, and membrane.

Head almost as long as width through the eyes (19:20), shorter than width across postocular tubercles (19:21.5). Anterior process stout, with parallel sides, notched anteriorly, reaching to the middle

of antennal segment I. Antenniferous tubercles moderately large, dentiform, acute, their exterior borders parallel, reaching to $\frac{1}{5}$ of antennal segment I. Eyes large, semiglobose, protruding. Post-ocular tubercles small, dentiform, produced beyond the outer border of the eyes. Vertex with "V"-form rows of fine granules, and laterad of them, with two (1 + 1) ovate, and finely granulate elevations. Antennae long, and slender, twice as long as the head (40:19). First segment robust, clavate; 2nd much thinner, tapering toward the base; 3rd subcylindrical, slightly dilated apically; 4th elongately fusiform. Proportions, I to IV, are: 12:7:12.5:8.5. Rostrum short, reaching to the base of rostral groove.

Pronotum much shorter than width across humeri (25:40); divided into two lobes by a thin, transverse sulcus. Fore lobe is distinctly narrower than the hind lobe (30:40). Collar clearly separated from the disc. Behind it is placed a short, subtriangular, almost an extended "V"-shaped, carina. Antero-lateral angles produced into lobes, rounded anteriorly and laterally, reaching forward as far as the collar. They are separated from the latter by deep incisures. Lateral border is doubly sinuate, and with a small tooth between sinuses. Lateral borders of the hind lobe convex, and slightly sinuate at the postero-lateral angles. Fore disc with two (1 + 1) oblique, granulate ridges at the bases of antero-lateral angles, and with two (1 + 1) callosities mesad of the latter. In the middle of the sulcus dividing both lobes is placed a small tubercle. Hind lobe finely granulate; a fine sulcus runs along the hind border of pronotum. The latter is straight in the middle, and angularly produced backward laterad of scutellum.

Scutellum short, wide, and semicircular, half as long as its width at the base (11:22.5). Disc is slightly raised, and granulate.

Hemelytra reach over fore border of tergum VII. Corium short, reaching $\frac{2}{3}$ of the length of scutellum; its exterior border is carinate. Membrane large, transparent.

Abdomen ovate, slightly longer than maximal width across segment IV (58: 54). Connexivum wide, and slightly reflexed. Connexiva II and III semifused together; others clearly separated from each other. PE-angles of connexiva II to VI progressively protruding, rounded; PE-VIII angularly produced backward, but not reaching the tips of paratergites. Paratergites subcylindrical, reaching to $\frac{2}{3}$ of cordate, declivous hypopygium. Spiracles II sublateral, and not visible from above; III to VIII lateral, and visible.

Legs unarmed.

Colour: head, pronotum, scutellum, femora, claws, and antennal segments I, II, and IV, are dark brown; abdomen light brown; the base

of ant. segment I, the whole III, tip of IV, and tibiae are ochraceous, partly infuscate.

Total length, 4.56 mm; width of pronotum, 1.6 mm; width of abdomen, 2.16 mm.

Holotype: ♂, Fiji Islands, Viti Levu—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Paratypes: 2 ♂, and 1 nymph, collected with the holotype; in the same collection, and collection of the author.

Carventus ovatus n. sp. is related to *C. malayensis* n. sp., but is smaller; anterior process of the head shorter, reaching only to the middle of antennal segment I; scutellum is semicircular, not subtriangular; PE-angles of connexiva more protruding.

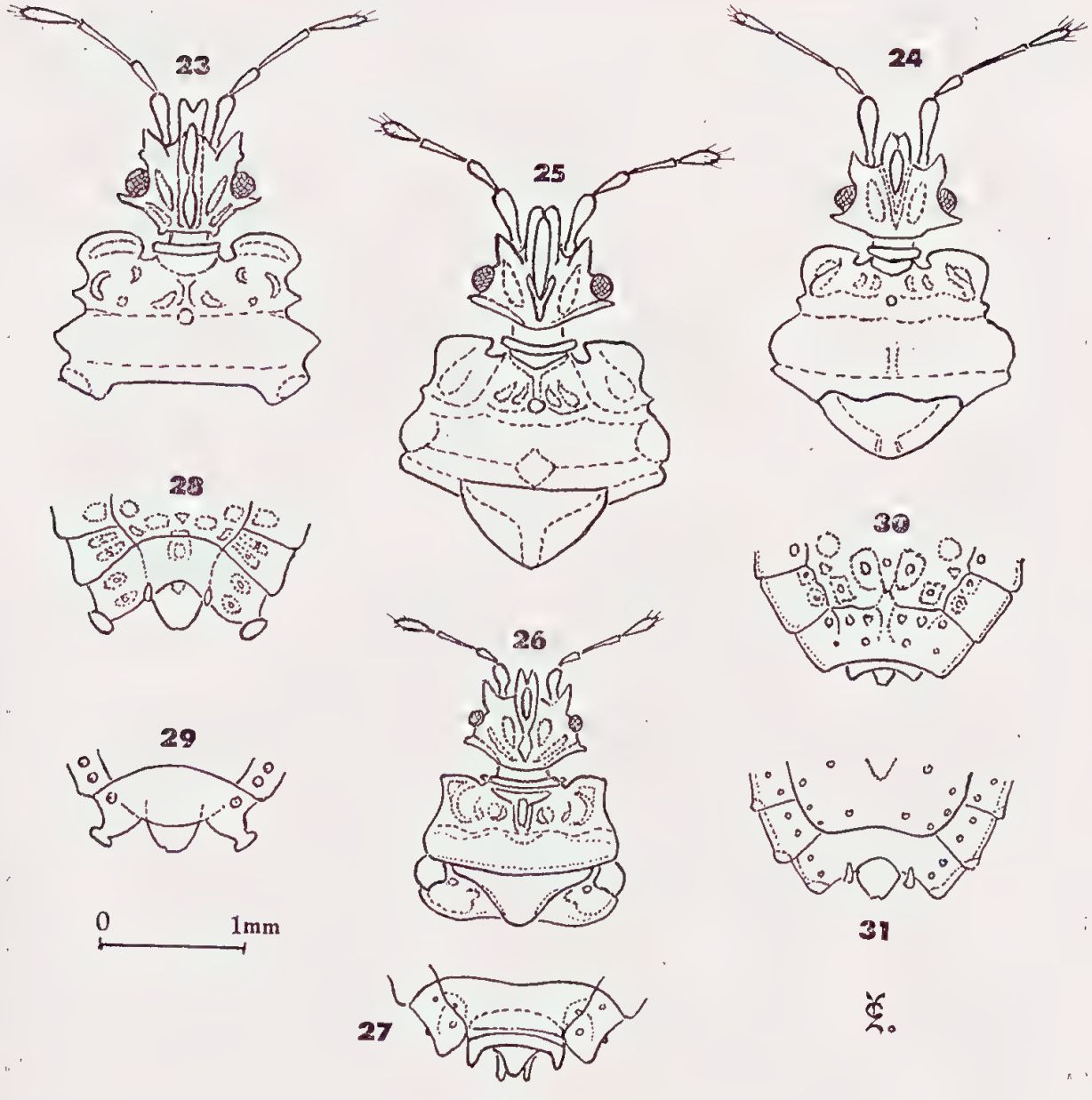
3. **Carventus robustus** n. sp.

Fig. 25

Male. Elongate ovate, rather robust; covered with brown incrustation, and accumulated dirt.

Head shorter than width through the eyes (♂—20:23, ♀—21.25). Anterior process robust, slightly constricted in the middle, and a little incised in front, reaches to $\frac{3}{5}$ of antennal segment I. Antenniferous tubercles dentiform, acute, divaricating, reach to $\frac{1}{4}$ of antennal segment I. Eyes large, semiglobose, protruding. Post-ocular tubercles small, dentiform, slightly produced beyond the outer border of the eyes. Vertex with a high median ridge, and with two (1 + 1) thin, lower carinae along the latter. Laterad of them are placed two (1 + 1) ovate, raised callosities. Antennae one and a half times as long as the head (30.5:20). Segment I robust, clavate; II and III tapering toward the base; IV fusiform. Proportions, I to IV, are: ♂—10:5:8:7.5, ♀—11:6:9:7. Rostrum short, reaching to the hind border of a wide, and deep, rostral groove, which is closed posteriorly.

Pronotum shorter than maximal width across humeri (♂—27:46, ♀—28:50). Fore lobe narrower than hind lobe (♂—37:46, ♀—38:50). Collar high, clearly separated from the disc. Just behind the collar is placed a narrow, transverse, granulate ridge; behind the ridge, on the median line runs a short and narrow sulcus, terminating with a high tubercle, placed on the interlobal depression. Laterad of the median sulcus are placed two (1 + 1) callosities, each of them bearing an oblique, granulate ridge. Antero-lateral angles form two (1 + 1) expanded lobes, truncate anteriorly, and rounded antero-laterally. Just behind these lobes are placed two (1 + 1) high, oblique ridges, divergent backward. Interlobal depression deep, and rather wide. Lateral borders doubly sinuate, with a large tooth between the sinuses.



Carventus malayensis n. sp., ♀, Fig. 23—head and pronotum.
Carventus ovatus n. sp., ♂, Fig. 24—head, pronotum and scutellum.
Carventus robustus n. sp., ♂, Fig. 25—head, pronotum and scutellum.
Carventus brachypterus n. sp., ♀, Fig. 26—head, pronotum, scutellum and hemelytra (pads); Fig. 27—tip of abdomen, dorsal aspect.
Acaraptera dimorpha n. sp., ♂, Fig. 28—tip of abdomen, dorsal aspect, Fig. 29—ventral aspect; ♀, Fig. 30—tip of abdomen, dorsal aspect.
Acaraptera (*Lissaptera*) *denticeps* n. sp., ♂, Fig. 31—tip of abdomen, dorsal aspect.

Hind lobe higher than fore lobe, granulate; a thin, transverse sulcus runs along hind border. Hind border straight in the middle, protruding backward laterad of scutellum.

Scutellum semicircular, half as long as its basal width (♂—13:25, ♀—15:28). Disc slightly raised, scabrous; median carina distinct on the hind half of the disc.

Hemelytra reach to the middle of tergum VII (♂), or to $\frac{1}{3}$ of tergum VII (♀). Corium rugose, reaches to $\frac{2}{3}$ of scutellum; its exterior border carinate, reflexed.

Abdomen slightly longer than its maximal width across segment IV (♂—58:55, ♀—69:68). Connexivum wide; segments II and III semifused together; others clearly separated from each other. PE-angles II to VI progressively protruding, rounded; PE-VII produced backward as subangular, apically rounded, and reflexed lobes, which do not reach the tips of paratergites. Paratergites (♂) conical, reaching to the middle of a subcordate, declivous hypopygium; the latter with a median ridge tapering backward. In the female, paratergites short, conical, rounded apically, reaching slightly over the middle of segment IX; the latter is short, and rounded apically. Spiracles II to VIII lateral, and visible from above.

Legs unarmed.

Colour: dark reddish brown; tibiae slightly lighter; tarsi yellow-brown.

Total length: ♂—4.64, ♀—5.44 mm; width of pronotum: ♂—1.82, ♀—2.00 mm; width of abdomen: ♂—2.20, ♀—2.72 mm.

Holotype: ♂, Fiji Islands, Tavanui—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Allotype: ♀, collected with the holotype; in the same Museum.

Paratypes: 2 ♂, 3 ♀, and 1 nymph, collected with the holo, and allotype; 5 ♂ & 1 ♀, Fiji, Viti Levu—A. M. Lea coll.; deposited in the same Museum and collection of the author.

Carventus robustus n. sp. is not closely related to any of Oriental species of *Carventus,* may be the nearest is *C. biroi* Kormilev, 1954, but it may be separated from the latter by: different shape of pronotum; all ridges and depressions of the latter are more pronounced; PE-angles of connexiva more protruding. The whole aspect of *C. robustus* n. sp. is that of sturdiness.

4. **Carventus minutus** Kormilev

Carventus minutus Kormilev, 1955, Rev. Ecuat. Ent. Par., **2**: 486.

Described from Deslacs Islands, it is now recorded from Papua.

1 ♂, N.E. Papua, Mt. Lamington, 1,300-1,500ft.—C. T. McNamara coll.

5. **Carventus australis** Kormilev

Carventus australis Kormilev, 1958, Jour. N.Y. Ent. Soc.: 66: 87.

3 ♂ & 2 ♀, Australia, Queensland, Mt. Tambourine—A. M. Lea coll.; 3 ♂, Australia, N. Queensland, Cairns—A. M. Lea coll.; 1 ♀, Australia, N. Queensland, Cairns; 1 specimen without tip of abdomen, Australia, N.S.W., Dorrigo.

6. **Carventus kirkaldyi** China

Carventus kirkaldyi China, 1930, Insects of Samoa, Part II, Hemiptera, fasc. 3: 109; Brit. Mus., London.

Described from Samoa, now is recorded from Fiji.

6 ♂, 4 ♀ & 4 nymphs, Fiji Islands, Viti Levu—A. M. Lea coll.

7. **Carventus brachypterus** n. sp.

Fig. 26-27

Female. Elongate ovate, brachypterous; the whole dorsal surface roughly granulate; incrustation almost absent.

Head slightly shorter than width through the eyes (18:19). Anterior process deeply cleft, genae being much longer than clypeus; reaches to the tip of antennal segment I. Antenniferous tubercles dentiform, acute, slightly divaricating; reaching to the middle of antennal segment I. Eyes small, semiglobose, protruding. Postocular tubercles blunt, separated from vertex by a fine sulcus; reaching to the outer border of the eyes. Vertex with a triple row of fine granules. Antennae short and slender, one and a half times as long as the head (26:18). Proportions of antennal segments, I to IV, are: 7:4:7.5:7.5.

Pronotum trapezoidal, half as long as its maximal width (17:34). Collar clearly separated from the disc. Antero-lateral angles lobulate, though the lobes are greatly reduced compared to macropterous species of the genus *Carventus* Stål; incisure between collar and antero-lateral angles also reduced, shallow. Lateral borders slightly sinuate before the middle, slightly convex after the middle. Hind border slightly convex. The whole pronotum, particularly the hind lobe, is reduced compared with fully winged *Carventus*: antero-lateral angles form subangular lobes, rounded at the tip, produced as far as fore border of the collar. Hind lobe is shorter, and only slightly wider than the fore lobe.

Scutellum subtriangular, short, and wide at the base (10:25). Lateral borders slightly sinuate, and subcarinate; disc convex, roughly granulate.

Metanotum consists of two (1 + 1) plates which are deeply depressed anteriorly, and bear an "S"-shaped transverse carina on each plate; their limits with scutellum and tergum I are formed by narrow, and moderately deep sulci.

Hemelytra reduced to small pads, without division into corium, clavus, and membrance. The latter is completely absent. Pads are convex exteriorly, and slightly excavate posteriorly; reaching to the middle of scutellum.

Abdomen longer than its maximal width across segment IV (60:49). Lateral borders regularly convex. Connexivum reflexed; PE-angles barely protruding; PE-VII subangularly rounded, and slightly produced backward. Connexiva I and II semifused, others separated. Terga I and II fused together, separated from the metanotum, and central dorsal plate, by fine sulci. Central dorsal plate consists of terga III to VI flat, slightly raised only along the median line. The first tergal gland opening is large, the 2nd reduced, the 3rd obsolete. Terga I and II roughly granulate. Tergum VII raised backward; along its hind border runs a double, fine sulcus. Tergum VIII very short and wide. Paratergites rather large, dentiform; segment IX with parallel sides, tricuspidate apically. Spiracles II to V ventral, and not visible from above; VI sublateral, slightly visible; VII lateral, and visible; VIII dorso-lateral.

Legs unarmed.

Colour: testaceous, partly darker; connexiva bicolorous; their outer borders dark brown anteriorly, and yellow posteriorly.

Total length, 4.28 mm; width of pronotum, 1.36 mm; width of abdomen, 1.96 mm.

Holotype: ♀, Tasmania, Manawah—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Usinger and Matsuda mentioned the existence of brachyptery in *Carventus* (1959: 120), but to date no brachypterous species has been described (to my knowledge). It is rather difficult to locate *Carventus brachypterous* n. sp. taxonomically because its pronotum is modified by brachypterism, but the head is typically that of a *Carventus*; connexiva I and II semifused as in the macropterous species; antennae and legs are also as in macropterous species.

Gen. **Acaraptera** Usinger & Matsuda, 1959

This curious, apterous genus was recorded from Samoa, Fiji, New Zealand, and adjacent islands. Now we have three more species from Lord Howe Island, a small island in the Southern Pacific between New Zealand and Australia. Usinger and Matsuda split this genus into three subgenera: *Acaraptera* sensu strictu, *Nesiaptera,* and *Lissaptera.* One of the new species belongs clearly to *Lissaptera,* but the other two, though with some difficulty, I have placed into *Acaraptera sensu stricto.*

One of the new species, belonging to *Acaraptera* s. str., shows a curious sexual dimorphism; the males have on the ventro-lateral side of connexivum VII two (1 + 1) large, obovate tubercles placed on a protuberance; these tubercles are absent in the females. Moreover in the males, sterna II and III are fused in the middle, but they are

separated in the females. Another new species, belonging to *Acaraptera* s. str., is represented only by the females, so it could not be proved if it also has this dimorphism. In *Acaraptera myersi* Usinger & Matsuda, 1959, the males do not have pedunculate, obovate tubercles, as in the abovementioned species, but on corresponding places may be seen ovate callosities.

The second new species differs from other *Acaraptera* species by a highly elevated median portion of the body, forming a stout ridge running from the pronotum to tergum VII, similar to some species of the genus *Biroana* Kormilev, 1957, but the pattern of small ridges on the pro, meso, and metanotum is more similar to that of *Acaraptera,* than of *Biroana;* also the body is not pilose, but only scabrous because of numerous small ridges, and fine punctures, so that I have decided to put it also in *Acaraptera.*

1. **Acaraptera dimorpha** n. sp.

Fig. 28-30

Male. Elongate ovate, rather flat; covered with greyish incrustation; apterous.

Head transverse, much shorter than width through the eyes (♂—15.5:21.5, ♀—16:22). Anterior process short, anteriorly cleft, genae being longer than clypeus; reaching to $\frac{1}{3}$ of antennal segment I. Antenniferous tubercles strong, acute, flat, and divergent; reaching to $\frac{1}{4}$ of antennal segment I. Eyes small, protruding. Postocular portions of the head produced into blunt teeth, reaching to the outer borders of eyes. Hind border slightly convex in a wide arc. Vertex with "V"-shaped carina, and laterad of it with two (1 + 1) ovate callosities. Antennae twice as long as the head (♂—31.5:15.5, ♀—29.5:16). Proportions, I to IV, are: ♂—10:6:7.5:8, ♀—10:6:6.5:7.5. Rostrum short, reaching to hind border of a shallow rostral groove.

Pronotum distinctly separated from mesonotum, much shorter than the maximal width across humeri (♂—9:30, ♀—10:32). Collar indistinctly separated from the disc, and in the middle produced backward as a median carina. Antero-lateral angles slightly expanded, and depressed, subangularly rounded; at their base run arcuate carinae (1 + 1) starting from the collar, and reaching to the hind border of the disc laterally. Disc itself is irregularly rugose. Median carina finely sulcate on median line.

Mesonotum wider than pronotum (♂—34:30, ♀—40:32); its lateral borders carinate, and divergent backward; median carina widening backward, and fused with a median elevation of metanotum, and tergum I. The latter is finely, longitudinally sulcate. Hind

borders finely carinate. Disc with six (3 + 3) semifused, depressed, irregular carinae, and deep depressions between the middle and outer carinae.

Metanotum forms two (1 + 1) large irregularly rounded plates separated by a median elevation. From the middle of the round plates run backward two (1 + 1) longitudinal carinae, produced posteriorly across terga I and II, and reaching central dorsal plate, dividing terga I and II into a median and two lateral portions.

Abdomen longer than maximal width across segment V (♂), or IV (♀) (♂—50:43, ♀—55:50). Tergum I separated from metanotum by a fine carina in the middle, and by fine sulci laterally. Tergum II separated from tergum I, and central dorsal plate by fine sulci. Central dorsal plate consists of terga III to VI, it is raised on the median line, and sloping laterally. It is provided with the usual pattern of callosities, surrounded by flat carinae. In the male, PE-angles of connexiva III to VI are slightly and progressively produced, and rounded; in the female, not produced. In the male, PE-VII is angularly rounded, and reflexed; on its ventro-lateral side are placed two (1 + 1) protuberances, terminating in obovate, shiny tubercles. In the female, lateral borders of abdomen evenly arcuate, without any protuberances. Paratergites, in both sexes, small, and blunt, directed obliquely upward in the male. Hypopygium elongate ovate, caudal in position, produced as far as obovate tubercles. Segment IX in the female small, rounded posteriorly, produced slightly beyond paratergites. Spiracles II and III are lateral and visible from above; IV to VII ventro-lateral; VIII terminal.

Meso, and metasternum, are fused in both sexes; sterna II and III fused only in the male, free in the female. Sterna IV to VII separated from each other.

Legs unarmed. Trochanters free; femora slightly inflated; claws with small arolia.

Colour: yellow brown; lateral borders of pro, meso, and metanotum, median elevation on terga I and II, flat carinae on central dorsal plate, PE-angles of connexiva III to VII, and tarsi, yellow. In the female, body dark brown to reddish brown, with even, yellow lateral borders from pronotum to tergum VII.

Total length: ♂—3.6 mm, ♀—3.82 mm; width of pronotum: ♂—1.2 mm, ♀—1.28 mm; width of abdomen: ♂—1.72 mm, ♀—2.00 mm.

Holotype: ♂, Lord Howe Island (Southern Pacific)—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Allotype: ♀, collected with the holotype; in the same collection.

Paratype: 1 ♂, collected with the holo, and allotype; in the collection of the author.

Acaraptera dimorpha n. sp. may be separated from *A. myersi* Usinger & Matsuda, 1959, from New Zealand, by its much larger size, by a different pattern of carinae, and depressions, on pro, meso, and metanotum, and abdomen; males also have pedunculate processes on PE-VII, which are absent in *A. myersi,* and replaced there by ovate, shiny tubercles.

2. **Acaraptera minuta** n. sp.

Female. Ovate, scabrous; raised on median line from pronotum to tergum VII. Head finely granulate; body very finely punctured, covered with thin incrustation.

Head shorter than width through the eyes (10:14.5). Anterior process stout, short, and subtruncate anteriorly, clypeus being very slightly longer than genae, reaching to $\frac{2}{5}$ of antennal segment I. Antenniferous tubercles very short, robust, reaching very slightly over the base of antennal segment I. Eyes very small, semiglobose, protruding; their facets are convex. Postocular tubercles small, blunt, almost reaching to the outer border of eyes. Vertex with a "V"-shaped carina. Antennae almost twice as long as the head (18.5:10). Antennal segment I robust, fusiform; II ovate; III and IV semifused together (fused in nymphal stage), III tapering toward the base, and petiolate, IV robust, pyriform. Proportions, I to IV, are: 9:2.5:3:4. Rostrum short, but robust, reaches to the base of the head.

Pronotum one third as long as its maximal width (7:22). Collar ill defined; anterior border truncate; antero-lateral angles rounded; lateral borders convex. Disc with a "T"-form median ridge, which is sulcate on median line; along lateral borders run two (1 + 1) robust ridges. A few raised, shiny callosities laterad of median ridge. Pronotum is fused with mesonotum in the middle, separated laterally by deep furrows, or depressions.

Mesonotum and metanotum are fused in the middle into a thin, high ridge; separated laterally by deep sulci. Median ridge sulcate on median line. Posteriorly it is connected with diverging ridges of tergum I. Mesonotum with ill defined carinae along lateral borders, and with four (2 + 2) raised, curved callosities on each side of median ridge, separated from the latter by deep depressions. Metanotum has six (3 + 3) similar callosities on the disc laterally, and even deeper depressions along the median ridge.

Abdomen shorter than width across segment IV (27:32). Tergum I is completely fused with metanotum, but separated from tergum II by a transverse depression. Tergum II is split into two (1 + 1)

ridges in the middle, and deeply depressed laterally. Central dorsal plate consists of terga III to VI; it is highly raised in the middle, forming a stout median ridge, abruptly sloping laterally. Laterad of median ridge are placed fine carinae, and depressions; each segment bears six (3 + 3) round, callous spots. Tergum VII has a thinner median ridge tapering, and sloping, backward. Connexivum wide, with a sublateral, longitudinal carina, sloping medially, and bearing on inner side round, callous spots. PE-angles not protruding; PE-VII rounded. Spiracles II, III, and VII lateral, and visible from above; IV to VI sublateral, but still visible; VIII terminal. Paratergites small, blunt, reaching to the middle of segment IX which is short, rounded posteriorly.

Legs robust, and unarmed.

Colour evenly testaceous; PE-III to PE-VI, and tarsi, are yellow.

Total length, 2.12 mm; width of pronotum, 0.88 mm; width of abdomen, 1.28 mm.

Holotype: ♀, Lord Howe Island (Southern Pacific)—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Paratypes: 3 ♀, collected with the holotype; in the same collection, and collection of the author.

3. **Acaraptera (Lissaptera) denticeps** n. sp.

Fig. 31

Male. Ovate, flat; head, antennae, and legs partially, finely granulate; rest of the body very finely punctured.

Head shorter than width through the eyes (17:22.5). Anterior process strong, forked in front, genae being much longer than clypeus and divergent; they reach to $\frac{2}{3}$ of antennal segment I. Anteniferous tubercles strong, acute, slightly divaricating. Eyes small, protruding, with convex facets. Postocular portion of the head produced into flat, acute angles, produced as far as outer border of the eyes. Vertex with two contiguous carinae, and laterad of them with two (1 + 1) ovate callosities. Antennae short, only one and a half times as long as the head (26:17); proportions, I to IV, are: 9:4:6:7. Rostrum reaches to the base of a shallow rostral groove.

Pronotum four times as wide as long in the middle (8:33). Anterolateral angles slightly expanded, and rounded, forming small, rounded lobes. Collar poorly separated from the disc. Along anterior, lateral, and posterior borders run thin carinae, slightly blurred at humeri. Disc uneven, finely punctured; with a low, ill defined, median carina, and with ten (5 + 5) small callous spots laterad of it.

Mesonotum and metanotum completely fused together, and with terga I and II, in one large plate, half as long as wide (23:42). Meso and metanotum are separated only laterally by fine sulci, evanescent before the middle of the disc. Disc is slightly longitudinally raised on the median line on meso, and metanotum, slightly depressed on tergum II; disc is provided with a few small, irregularly shaped, symmetric, callous spots. Lateral borders of meso, metanotum are slightly swollen, and fused with connexivum II.

Abdomen (inclusive of terga I and II) as long as wide across segment IV (45:45), flat, slightly raised on median line, sloping laterally. Central dorsal plate subrectangular, with rounded posterolateral angles. Disc finely punctured, and provided with 20 (10 + 10) small, round, callous spots, distributed into six (3 + 3) rows. Connexivum wide, slightly raised laterally; all segments clearly separated from each other. PE-angles II to VI slightly protruding, and rounded; PE-VII angularly rounded, and produced backward. Paratergites small, clavate. Hypopygium conical, slightly produced beyond PE-VII. Spiracles lateral and visible from above on II, III, VI, VII, and VIII; sublateral and not visible on IV and V.

Legs unarmed.

Colour: ferrugineous to chestnut-brown; PE-angles of connexiva II to VI, and tarsi yellow.

Total length, 3.64 mm; width of pronotum, 1.32 mm; width of abdomen, 1.80 mm.

Holotype: ♂, Lord Howe Island (Southern Pacific)—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Acaraptera (*Lissaptera*) *denticeps* n. sp. may be separated at once from *A.* (*L.*) *completa* Usinger & Matsuda, 1959, by the developed postocular tubercles, which are almost absent in the latter.

REFERENCES

Usinger, R. L. and Matsuda, R., 1959: Classification of the Aradidae (Hemiptera-Heteroptera); London, British Museum, VII—410 pp., 101 figs.

RESUMEN

El autor ha estudiado un importante lote de los Arádidos (Hemíptera) de las colecciones del Museo de Australia del Sur en Adelaide. Debido a la cantidad grande de las especies estudiadas, en este trabajo erán tratadas solamente las subfamílias Isoderminae, Prosympiestinae, Aradinae, Calisiinae, Aneurinae y Carventinae, dejando a la subfamília Mezirinae para el trabajo próximo. En este parte erán descriptas 14 especies nuevas para la ciencia, procedentes de Australia, Nueva Guinea, Fiji, algunas islas pequeñas del Pacífico Meridional y Malásia.

ARCHAEOLOGICAL STONE IMPLEMENTS FROM A LAGOON BED, KANGAROO ISLAND, SOUTH AUSTRALIA

By H. M. COOPER, Honorary Associate in Anthropology,
South Australian Museum

SUMMARY

This paper records the presence of a series of stone implements discovered upon the bed of a fresh-water lagoon situated on Kangaroo Island. Reference is made to the principal types and two possible explanations for their existence in this unusual situation are discussed.

A general description of the Kangaroo Island stone material culture is included for comparative purposes.

The topographical features and vegetation of the region surrounding the lagoon are referred to briefly.

TOPOGRAPHY

The topography of the area in the vicinity of the unnamed fresh-water lagoon, upon the bed of which the stone implements were found, is portion of a relatively low undulating plateau, about 300 feet above sea level. This is the dominating feature of the surrounding country.

Fresh and salt-water lagoons and swamps, usually dry in a summer season after an average annual rainfall of about 23 inches, occur here and there in some of the larger depressions. The surface soil is often loamy in character and in places somewhat shallow. Travertine limestone (kunkar) is exposed upon the surface of many of the ridges mostly in the form of large quantities of weathered out blocks. Deposits of lateritic gravel, often of considerable depth, occur in many places. This gravelly material sometimes exists in the form of large and small partly consolidated blocks and lumps. There are a few scattered outcrops of quartzite, sometimes flaggy and friable, also weathered out blocks of the same material which in a few places are interspersed with large massive pieces of milky vein quartz.

In some localities whitish sand overlies heavy, almost impervious clay and in these areas there exist many small depressions or claypans which retain surface water for a considerable period after rains. These valuable little water supplies, as will be mentioned later, were favoured as temporary camps when the former native inhabitants wandered about the countryside.

BOTANY

The vegetation around the lagoon and in the adjoining area is characteristic of this part of Kangaroo Island, the dominant large trees being *Eucalyptus cneorifolia* (Eucalyptus Oil Mallee), *Eucalyptus diversifolia* (White Mallee), *Eucalyptus cosmophylla* and *Casuarina stricta*. The dense scrub, almost impenetrable in places, includes *Xanthorrhoea tateana* (Yacca), *Myoporum insulare* (Native Juniper), *Correa* spp., *Callistemon macropunctatus* (Scarlet Bottlebrush), *Banksia ornata, Banksia marginata, Melaleuca* sp. (Teatree), *Acacia* (several handsome species) and numerous other shrubs, bushes and creepers.

The natural scrub, however, is rapidly being removed in order to provide additional cleared land for pastoral and agricultural purposes.

LAGOON BED CAMP-SITE. GENERAL DESCRIPTION

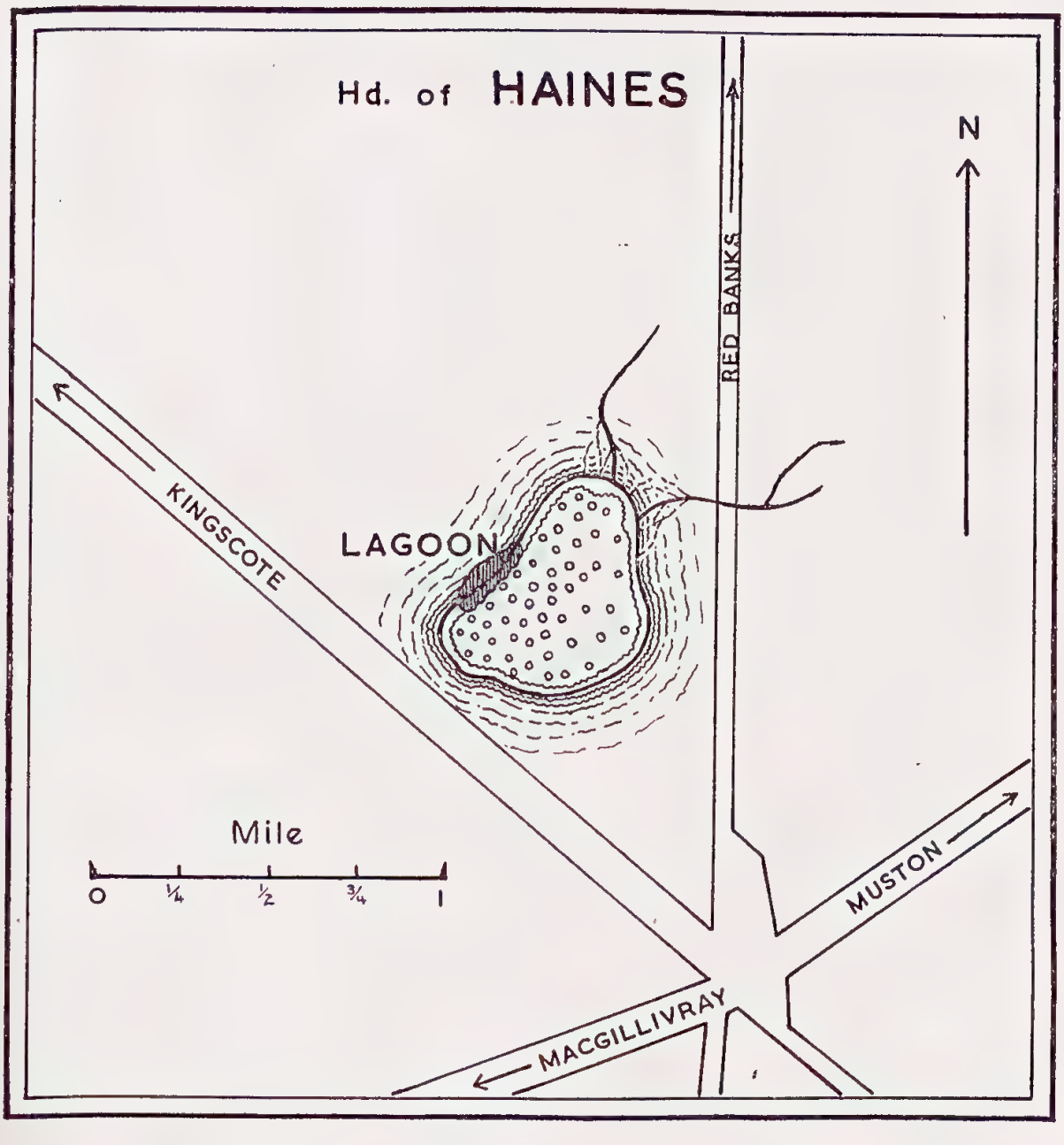
An inferior form of quartzite—the country rock of the vicinity—which occurs in places upon rising ground along the northern side of the lagoon, in the form of small isolated outcrops and scattered blocks, tends by exposure to rot and become friable in some places, as already described. This poor quality rock was employed occasionally in the manufacture of large implements such as fig. 1, 2 and 4, probably in the absence of suitable transported material such as fine-grained quartzites in the form of water-worn round beach pebbles which the aborigines transported from scattered places along the shore-line. This material, so attractive to the Kangaroo Island natives, was used by them almost exclusively in the manufacture of their large pebble chopper implement industry.

Vein quartz stones of various shapes and sizes occur upor rising ground sloping gradually upwards on the northern side of the lagoon which is approximately one third of a mile in length (see accompanying sketch). A large quantity of this material also exists along the south-western shore in the form of an extensive bed, both a little above and a little below the clearly defined marginal edge of the lagoon. The smoothed and sometimes rolled surfaces of these stones, irregular in shape and of various sizes, appear to indicate their subjection to water action extending over a considerable period of time, which small waves upon the surface of the lagoon, caused by wind storms, would tend to increase. These fragments are coated with a rusty brown layer, lateritic in origin, but breaking the exterior discloses their respective colourations.

This interesting strip of vein quartz, so conveniently situated, was probably the main source of raw material supply for the production

of implements, mostly small, found upon the floor of the lagoon. (The more correct term—vein quartz—is abbreviated to quartz or milky quartz in the remainder of this paper.)

The exterior surfaces of the quartz stones, which occur upon the ridge adjoining the lagoon's northern side, have retained their natural surface colouration with the exception of a few which seem to have been affected by the presence of patches of lateritic gravel in their vicinity. The quality of the quartz in this place appears to be superior to that upon the lagoon bed.



The floor of the lagoon is overgrown with a thick growth of a native reed (probably *Chorizandra enodis*) which has produced a dense, deeply interwoven solid mat of roots.

The surface discolouration deposited on the quartz stones, lying upon the lagoon bed, is probably due to their immersion for a considerable period of time, in water containing iron derived and washed down from patches of laterite occurring upon rises which border it and also perhaps from water running into the lagoon from the watercourse.

The principal water supply to the lagoon at present has its source in a small watercourse, shown upon the accompanying map, which drains some of the country to the north-east. This intake is augmented somewhat by a small scour which runs down a little to the north of the watercourse after which its flow enters the lagoon in the same locality. Additional water formerly ran into its south-western corner but the small supply from this quarter has now ceased owing to structural alterations to the adjoining main highway and as some of the water which formerly flowed down the north-east creek has been diverted and diffused, the volume reaching the lagoon will be appreciably less in future when compared with the quantity captured under earlier natural conditions.

The lagoon occupies the whole of the depression in undulating country and is encircled by an almost continuous sloping ridge of irregular height which attains a maximum elevation of about 40 feet.

A considerable number of stone implements, chiefly the large trimmed pebble types of Kangaroo Island, Cooper (1943) were discovered by the writer upon the eastern and southern portions of the encircling ridge, on sandy cultivated ground, in the course of many examinations in the period 1934-1962. During these years the dense matted growth of reeds and roots upon the bed of the lagoon obscured all traces of any former occupation, in the form of stone implements, the existence of which remained unsuspected until 1962 when its floor was laid bare by fire.

The depth of water amounts to a maximum of about 3 feet at the close of a winter of average rainfall after which it gradually dries out during the early course of the following summer.

The lagoon, however, after heavy winter rains occasionally retains water during the whole of the ensuing dry season but owing to the lack of rain in 1962, when almost drought conditions prevailed on Kangaroo Island, it remained dry throughout—an extremely rare occurrence.

This favourable climatic condition enabled the successful removal to be carried out, by fire, of the dense mass of reeds upon the bed of

the lagoon revealing the existence there of many stone implements, both large and small, briefly referred to earlier in this paper, together with discarded flakes and miscellaneous rock material.

The unusual situation in which these implements were found, that is upon the bed of a lagoon subject to regular inundation, is most unusual and directly contrary to the aborigines' practice of carefully avoiding places liable to flooding but who selected instead, elevated sites for their encampments. Two possible explanations for the existence upon the lagoon floor of all the essential components of a stone material culture—hammer-stones, trimmed and untrimmed flakes and cores—are discussed in detail later in this paper.

The distribution of the implements upon the bed of the lagoon is widespread as indicated upon the sketch although most were found along the western shore in the vicinity of or directly upon the quartz deposit itself, already mentioned, where detecting and collecting specimens under these circumstances proved most difficult. (It is desirable to examine, as far as possible, partly buried or obscured stones upon the surface of a camp-site, however unattractive at first sight they appear to be, otherwise valuable specimens from time to time will be passed by unnoticed). An additional layer of similar quartz stones, also iron stained, was found to exist below the closely matted root mass at scattered places in the same area but a somewhat brief examination failed to disclose the existence of any prepared implements there.

The small quartz implements discovered upon the lagoon bed, amounting to approximately 200 in all, vary greatly in shape as indicated by the figured specimens in this paper. They have been prepared from small, apparently fragmentary stones in the form of a trimmed core or flake. The size, shape and general appearance of the implements suggest that the nearby quartz deposit upon the lagoon bed was the aborigines' source of supply or at least a major portion of it.

The relative positions of the trimmed cutting, scraping or sawing edges are generally dependent upon the nondescript shapes of the stones chosen, there being little if any indication of premeditated, symmetrical trimming. It is impossible in most cases, to produce implements, under these circumstances, of any one particular type which closely resemble each other in form. The principal aim of the native tradesman in the production of implements of this nature, however, appears to have been solely one which would yield a simple but effective straight or curved cutting, scraping or sawing edge, the shape of the original stone or flake or finished production being of secondary importance.

This method and form of trimming stones and flakes, mostly small and often of nondescript shapes, may be observed upon Kangaroo Island in other situations. The incidence of flake-making milky vein quartz cores of good quality upon the lagoon bed is very small which explains the existence in that locality of core and flake implements derived from inferior quartz stones and a scarcity of those made from suitable flakes. There are other camp-sites upon the island, however, where milky vein quartz flake-making cores, of good quality, are numerous and in consequence there is a marked increase in the number of superior flake implements in those places, some primarily trimmed and others secondarily trimmed.

Many of these primarily trimmed flakes are so keenly edged and of such useful shapes that the question of their being deliberately made, and in consequence used, should be given consideration. Some possess chipped and damaged edges suggesting wear. The reason for this divergence in the relative numbers of small flake and core implements, although by no means important, is interesting. It appears to be largely dependent upon the quality of the quartz locally available which differs appreciably in the various localities from poor at the lagoon bed deposit—where much of it is coarse, gritty, impure and uneven in composition—to good at other places, particularly where flake-making cores are plentiful and of superior quality, such as those mentioned previously.

Some of the small quartzite implements from the lagoon bed such as shown in fig. 9, 18 and 20 may have been derived from either of two sources: (1) from random flakes struck off transported fine-grained quartzite pebbles during the process of shaping them into the large pebble choppers of the Kangaroo Island industry: (2) from deliberate flakes struck off fairly small quartzite cores which occur occasionally upon some camp-sites. Fig. 15 is an example. The neatly executed secondary trimming upon them is due to the superiority of the rock employed which possesses a good conchoidal fracture. It certainly does not necessarily imply greater skill on the part of the operator nor does there appear to be any evident reason for believing that they represent another and more refined Kangaroo Island material culture period.

NOTES ON THE MATERIAL CULTURE OF KANGAROO ISLAND

The simplicity in form of the large and small Kangaroo Island stone implements and the absence of many refined types, so widespread upon the mainland, probably associates them with a corresponding simplicity in the design and limited variety of the wooden hunting,

fighting and domestic implements in use there at that time. If this is true, these could have been restricted to little more than elementary forms of javelin type spears, thrown directly by hand, clubs, shields and a few essential domestic objects such as food vessels and digging sticks and also others for various purposes which the climate, if different from that at present prevailing, would have demanded. It is possible, therefore, that the inhabitants of Kangaroo Island had no knowledge of the light spear (woomera thrown), the boomerang, polished stone axe-heads and other refined constituents of later periods which appear to have been similarly unknown to the aborigines of Tasmania—also an isolated community.

It may be useful to refer briefly to earlier discoveries of the archaeological stone implements of Kangaroo Island before describing those found upon the floor of the fresh-water lagoon and discussing any possible deductions relating to their existence there.

Captain Matthew Flinders, R.N., who discovered and named Kangaroo Island in March 1802, correctly determined that it was an uninhabited land at the time of his arrival, basing his conclusions upon the absence of smokes—definite proof of the existence of natives on the mainland—the fearlessness of the kangaroos in striking contrast to their timidity on the continent—and the usual signs denoting the presence of primitive man. Subsequently, however, proof of a former native occupation was disclosed by the discovery of some hammer-stones (Howchin, 1903) and later by the finding of interesting large hand axes or choppers made from water-worn pebbles, first described by Tindale and Maegraith (1931) and Cooper (1943). Further intensive search revealed that they represented the dominant large type in the Kangaroo Island (native name Karta) culture, termed Kartan by Tindale.

The existence of a well established small type industry, an indispensable part of any stone implement culture, however primitive, remained obscure with the exception of a few specimens, chiefly made from quartzites, found by the writer during 1934-1939. The discovery of many small flake-making milky quartz cores upon several camp-sites, at a later period, however, disclosed the existence of numerous flake implements associated with them which, owing to the roughness of their trimming, and nondescript shapes, had been passed by unnoticed, as already referred to. Some of these were described by Cooper (1960).

It is most difficult to control the removal and direction of tolerably good flakes, by means of a hammer-stone, from blocks of quartz unless of fairly good quality, owing to the irregular nature of the rock. The occurrence of quartz, strewn in large quantities upon the surface over

large areas on Kangaroo Island, explains the reason for its use, despite its inherent limitations, in the production of many small implements, made necessary by the absence or scarcity of more suitable material.

The trimming method adopted and the final nondescript shapes of the implements produced, found upon the lagoon bed, as described above, although they may appear to be somewhat primitive and immature, are attractive by the reason of their simplicity and there is no evidence to suggest that they failed to accomplish successfully, the preparation of the wooden implements of the current period and other work which their use required.

Many stone implements designed in this manner, may appear at first glance, to workers accustomed to more advanced types, to be too casual and primitive to function with efficiency and their actual existence in the field, at least primarily, could be easily overlooked.

This simple trimming may also be observed in the preparation of certain large archaeological trimmed core implements found upon Kangaroo Island, at Hallett Cove and elsewhere on the nearby mainland.

The acceptance of these types as implements, formerly considered rather questionable, is now firmly established, following the discovery in more recent years of so many similar examples both large and small.

The elementary technique described above is in marked contrast to that of many of the more refined and additional implements of later periods which received careful primary and secondary trimming, to ensure that all conformed, as nearly as possible, to predetermined essentials including shapes. These advances in the functions of stone implements probably ran concurrently, in a general way, with additions to and improvements in the earlier wooden and other material culture fields.

The collection of certain apparently casual stone material, hitherto unnoticed or rejected, but which, after a subsequent examination confirms the presence of a definite type, is most important and the gathering of a large number of such specimens—sometimes deemed unnecessary—upon which to base a firm opinion, either positive or negative, is vital. This can hardly be effective if the examination is confined to a very few available examples, any decision so made rendering it liable to criticism.

The absence of sufficient reliable evidence makes it impossible to date the occupational period of Kangaroo Island, the only unassailable proof at present being the stone implements which survive it. The reason for the disappearance of the former inhabitants and the duration of their occupation are also unknown.

Kangaroo Island, over 90 miles in length and separated from the mainland by a narrow strip of sea, merely nine miles in width, was uninhabited at the commencement of the European occupation, significantly incomparable with the wide distribution of natives upon the Australian continent and also in Tasmania at that period.

It is not yet clear from a study of the implements—many of which have been discarded owing to their severely worn condition and the necessity for replacement by others—to determine whether the occupation was one of considerable duration and the population correspondingly small or, alternatively, whether it was shorter and the natives more numerous.

The occupational pattern disclosed by their camping places is an interesting one. The principal settlements, somewhat limited in number and probably semi-permanent at least, are indicated by the concentration of many implements, including hammer-stones, upon scattered but attractive spots chiefly adjoining inland creeks, swamps and lagoons. Small groups of implements occur at many other places but these seem to indicate temporary camps made by people from the main sites when wandering about the countryside during hunting expeditions.

These temporary camps include some interesting little claypan depressions (referred to in the topography section) which retain surface water for a considerable time. Here and there, two or three large pebble choppers and perhaps a hammer-stone or two, may be seen lying near the margins of these valuable water supplies, perhaps disclosing the former presence of small parties of wandering native hunters.

Stone implements being the only tangible evidence, it is most difficult or impracticable to date the occupational period, as already mentioned, the only other possibility at present being the discovery of certain sea-shells perhaps representing food remains. This has not yet been determined. There remain, however, several other aspects of some significance which may assist in assigning the occupation to a fairly remote date. The non-existence, up to the present time of any former trace on Kangaroo Island of the Dingo, a recent arrival in Australia, seems to suggest that the habitation of the island, represented by the stone implements, pre-dates the coming of this animal, provided that the islanders crossed over from the mainland either on foot or by wading before it was cut off and assumed its present form.

Although the large stone implements are abundant upon inland sites on Kangaroo Island as already described, no traces of them have yet been found upon its long stretches of white recent coastal sand-

dunes. This was a type of location so highly attractive to the aborigines of recent periods upon similarly placed shore-line dunes along the nearby mainland, as made evident by their now abandoned and widespread camp-sites. These dunes, similarly to those upon the island, also appear to be devoid of large archaeological stone implements but they commence to occur (upon the mainland) as soon as closely adjacent rising ground or cliff tops are reached. Localities include Hallett Cove, at the head of Gulf St. Vincent, Cape Jervis and elsewhere.

The heights and other topographical features of these mainland sites are significantly comparable with those upon the island and this, if finally substantiated regarding Kangaroo Island, might indicate that the occupational period there could have pre-dated the formation of its recent coastal white sand-dunes.

The scanty evidence available at present may favour, therefore, an early dating for their arrival, that the natives were few in number, consisted of small wandering communities and groups and that their habitation of the island lingered on over a considerable period of time.

THE LAGOON BED SITE. DISCUSSION

The reason for the existence of a considerable quantity of large and small implements upon the lagoon floor, together with hammer-stones and waste flakes, is difficult to determine. Two of the most important problems involved, not yet manifest, are their time dating and in close relation to it the climatic conditions prevailing. It seems advisable, therefore, to attempt little more at this time than discuss some possibilities relating to the existence of the material upon the bed of a lagoon only habitable, at least during recent years, for limited annual periods, ranging from nil to six or seven months with one definitely known exception already mentioned.

The natives of Kangaroo Island, as already stated, chose for their camp-sites rising ground around swamps and lagoons and upon the banks of creeks and watercourses. The occurrence, therefore, of many implements along the ridges overlooking the lagoon bed, as described in this paper, is conventional in its situation.

The writer, after examining the topography of the surrounding country as carefully as time would permit in the course of several visits, offers two alternative possibilities, both conjectural, to account for the existence of many stone implements upon the lagoon's bed.

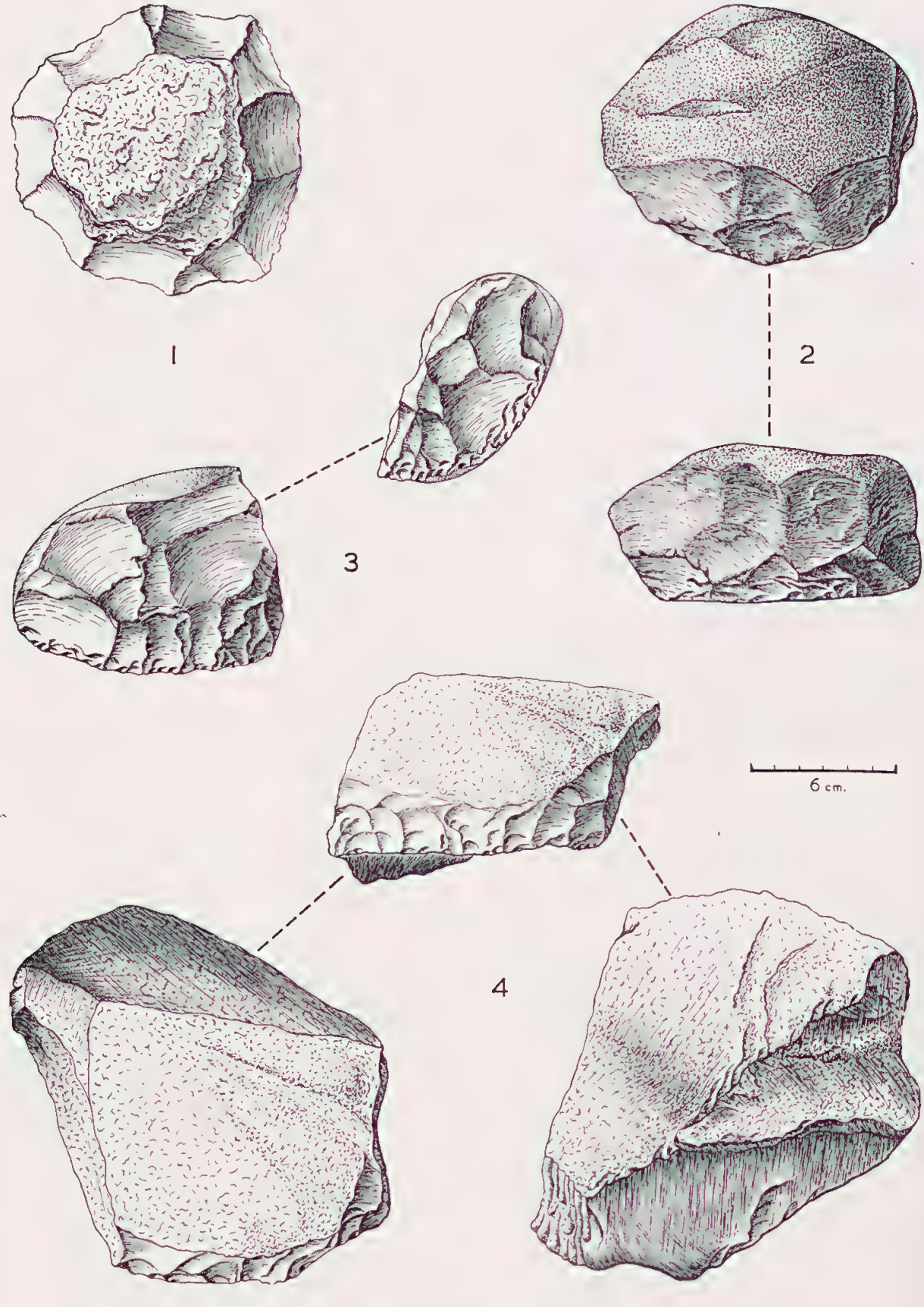
(1) It may have possessed some attraction, somewhat supposi-tional at present without knowledge of climatic conditions prevailing at

that time, such as an arid period, if one or more did occur during the occupation, either as an alternative or combined camp-site in connection with that which formerly existed upon the adjacent ridge. Another possible attraction may have been the possibility of procuring water from wells dug in the bed of the lagoon after its disappearance from the surface. The permanent green appearance of reeds and undergrowth in a small hollow over clay suggests the presence of water at shallow depth. The existence and utilization of vegetation growing upon the lagoon bed, for domestic purposes, may be considered and also the possible presence there of certain vegetable foods perhaps not available in the surrounding higher country. Most of these suggested deductions might need revision should climatic conditions prevailing during the occupational period become better known.

It seems rather surprising that implements of the various types would have been left upon the floor of the lagoon instead of being temporarily removed if it were liable at that time to periodic flooding. If however, it were dry for a long period or periods whilst occupied, due to aridity, the removal of the implements during such occasions would have become unnecessary and, similarly, if a dry period were in progress at the time of its relinquishment, perhaps the result of some now unknown calamity related to their ultimate disappearance. Under these circumstances the implements could have been *in situ* when abandoned and discovered later.

(2) The scattered situations of the implements, hammer-stones, waste material and fairly large flat slabs, possibly used for some domestic purpose, upon the lagoon bed, appeared to be too orderly to have been caused by the action of flowing water in transporting them from their original positions elsewhere. The extensive strip of quartz stones upon the lagoon bed (as already described) is compact and not widespread as are the implements. It seems reasonable to consider that this strip of stones, so conveniently situated, was the source from which the small implements or at least most of them, were derived. This is strengthened by the existence amongst this bed of some of the larger stones which show evidence of having been shattered by hammer-stone blows and also by the presence in the same place of a few cores from which flakes had been struck for implement making.

The writer, in order to ascertain whether the implements might have been washed down from elsewhere, examined the small watercourse which drains some of the country to the north-east but no evidence was discernible to indicate that they reached the lagoon from that direction nor was there any quartz supply seen in the area.

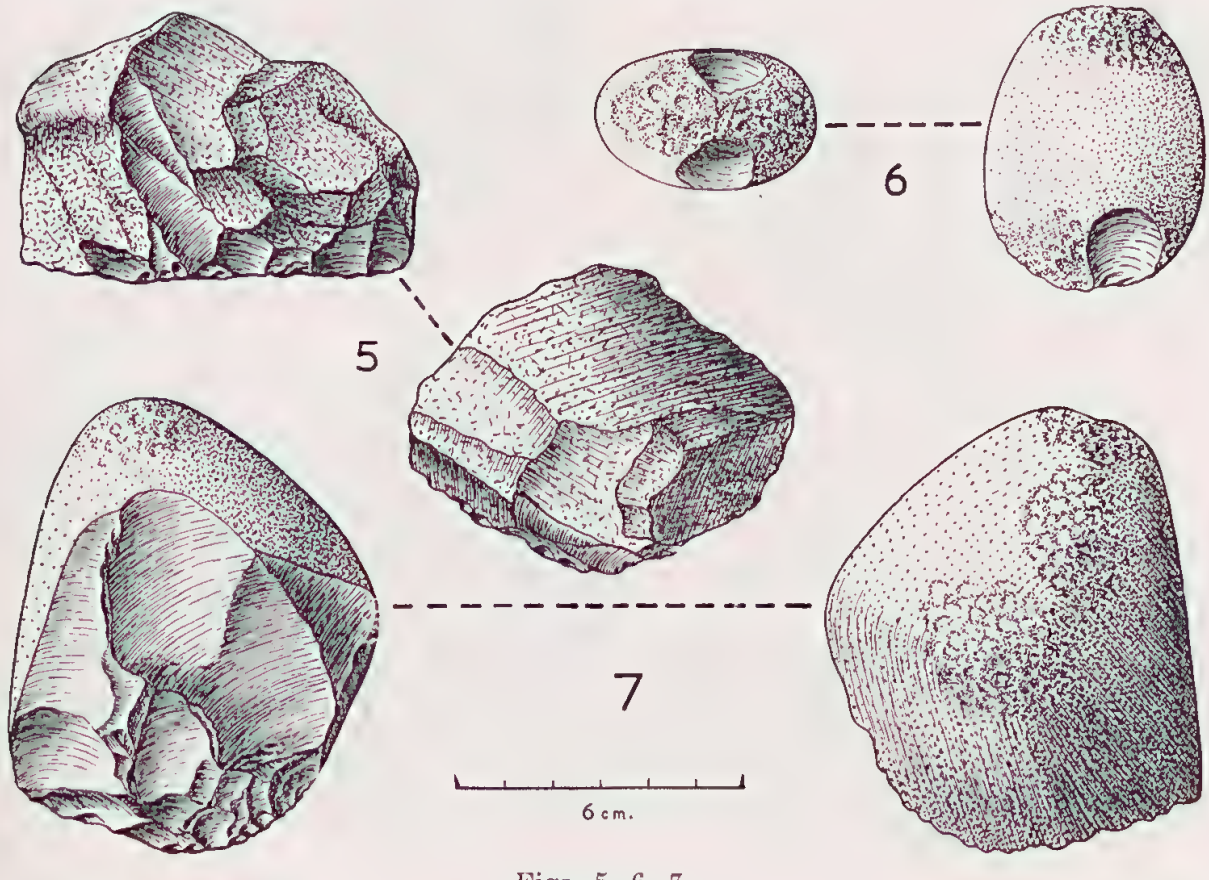


Figs. 1, 2, 3, 4.

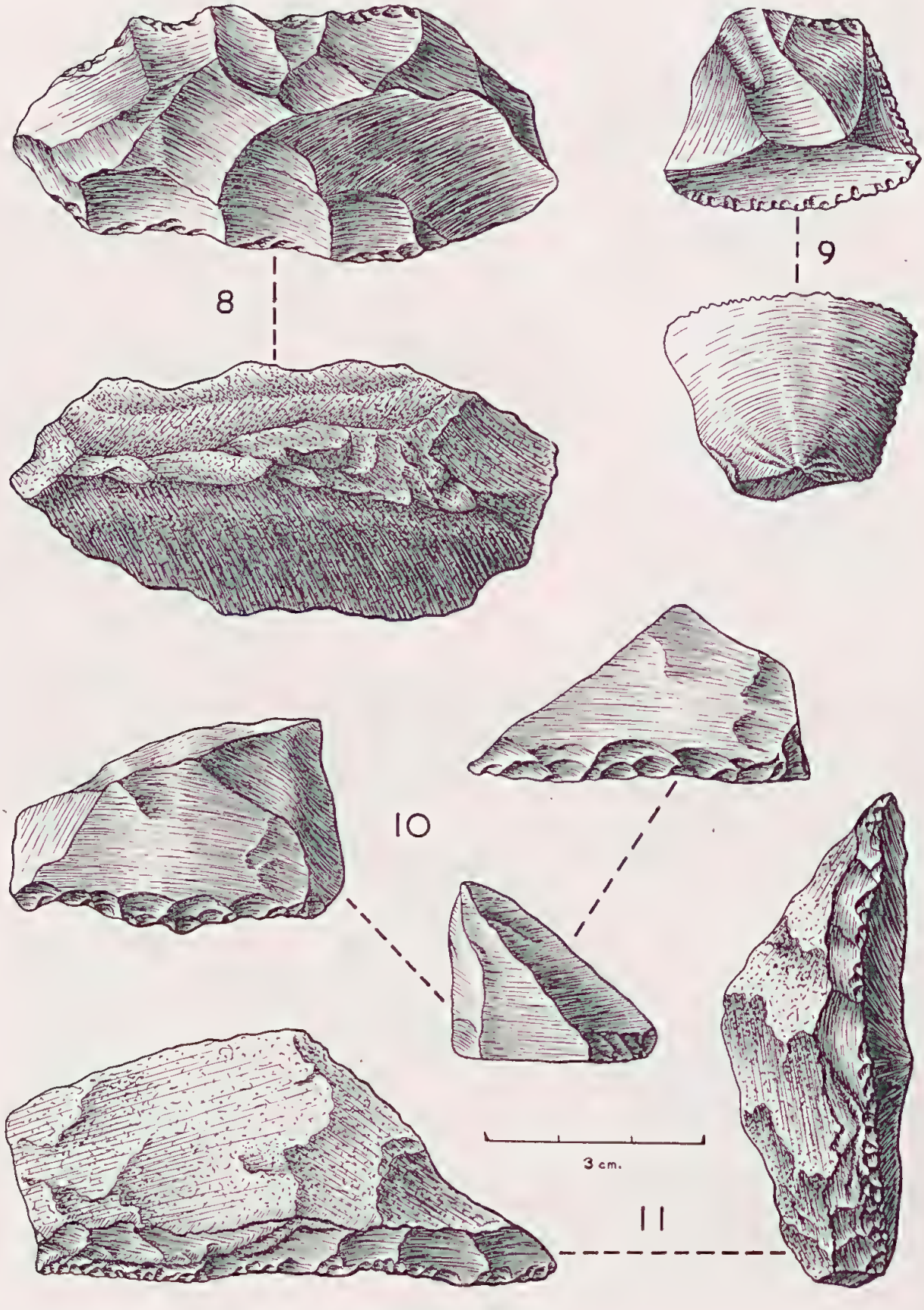
There does not appear to be any indication elsewhere of sufficient water flow to wash down and deposit in a totally new position, stone implements, particularly the larger ones, upon the lagoon bed unless all traces of this have now disappeared.

The location and distribution pattern of the implements discovered here, supported to some extent by local topographical features, seem to favour a deduction, admittedly far from proven, that they have not been redeposited upon the bed of the lagoon after removal from their original position by water flow but have remained *in situ* since the time of abandonment by their former owners.

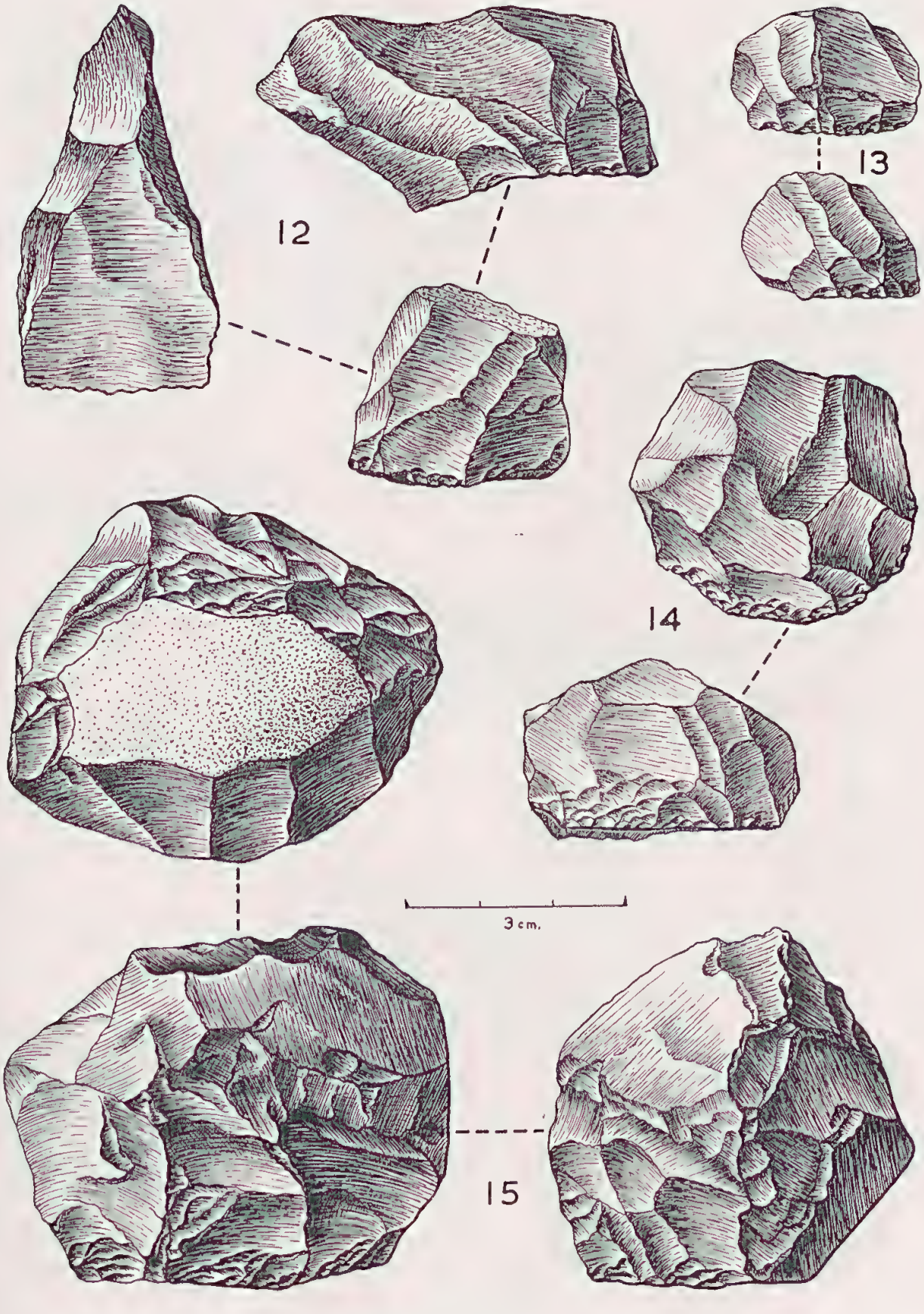
It would be dangerous to ignore however the possibility that some other explanation, perhaps rendered obscure by the passage of time and not necessarily related to those now being considered, may have had an important bearing upon the reason for the existence of these relics—devised by primitive man—upon the bed of a fresh-water lagoon.



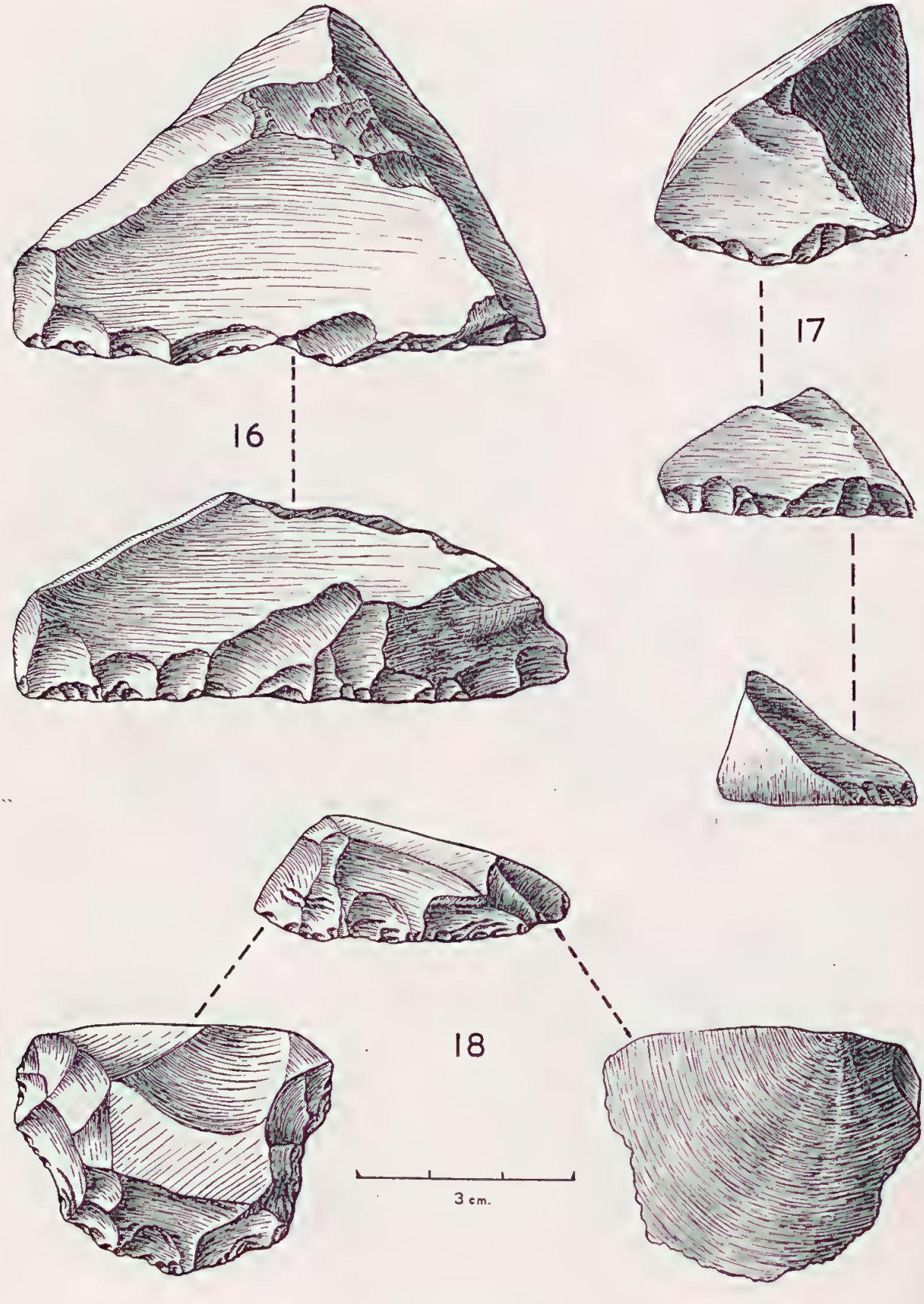
Figs. 5, 6, 7.



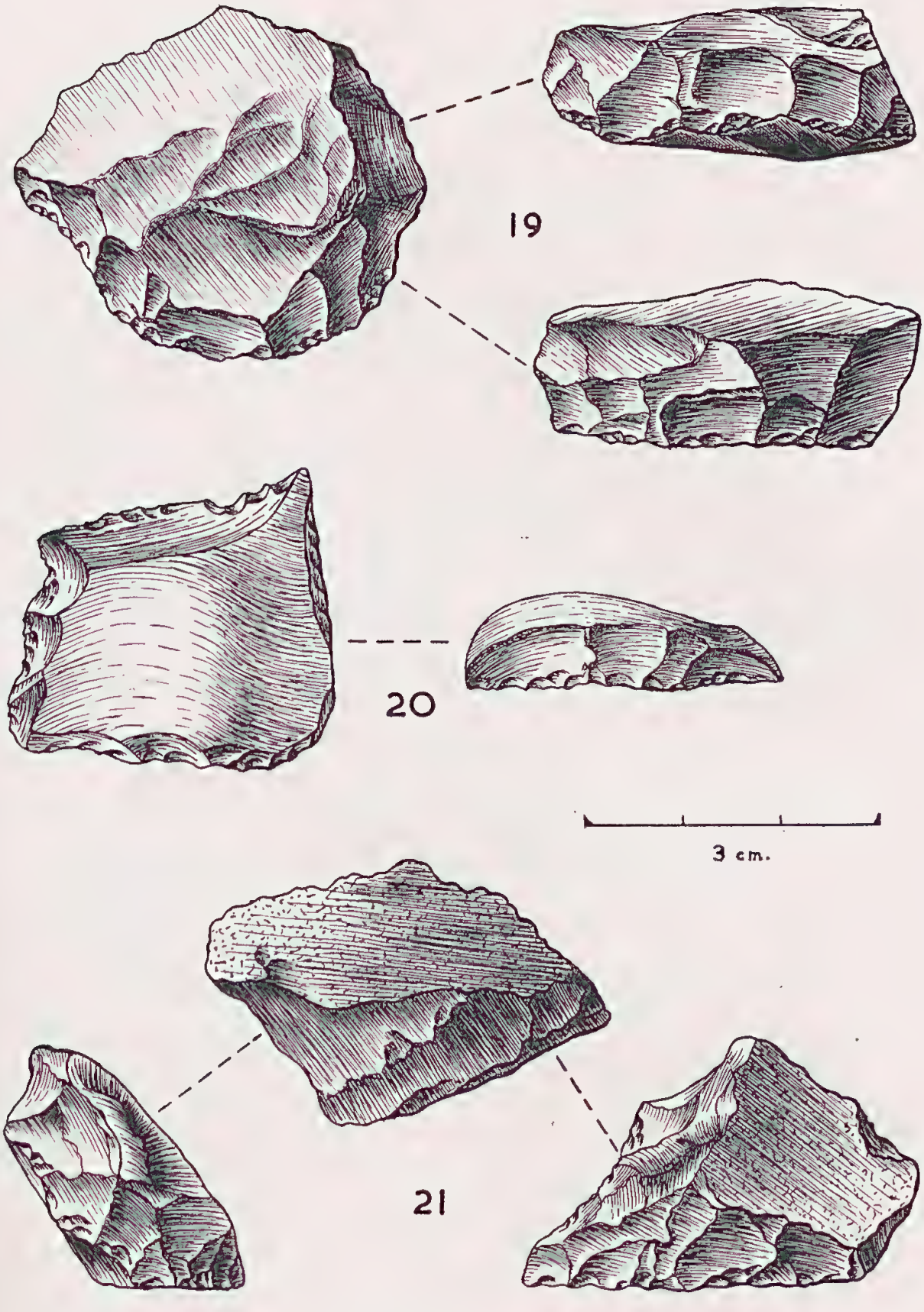
Figs. 8, 9, 10, 11.



Figs. 12, 13, 14, 15.



Figs. 16, 17, 18.



Figs. 19, 20, 21.

DESCRIPTION OF FIGURED SPECIMENS

Fig. 1. Made from a flat piece of rock; badly weathered. There is a little evidence of use as a hammer-stone upon the nether side as indicated by pit marks. This dual use is characteristic of many large Kangaroo Island stone implements. The weathering has almost obliterated the trimming.

Fig. 2. A flat core implement with stepped trimming along its working edge.

Fig. 3. Derived from a durable fine-grained quartzite pebble with the typical stepped secondary trimming of the island's pebble chopper industry although this specimen is not characteristically symmetrical in shape. There is distinct evidence on its under surface of casual employment as a hammer-stone.

Fig. 4. Made from an irregular block of country rock. It has a fairly straight working edge with clearly defined secondary trimming. This simple technique is identical with that which has been found at Hallett Cove. Its weight, 3¾ lb., is not unduly heavy for Kangaroo Island implements which occur to a maximum of at least 7 lb. *Vide* Cooper (1943) for comparative weights.

Fig. 5. A flat milky vein quartz core of fairly good quality with stepped secondary trimming around half of its basal margin.

Fig. 6. A small water-worn pebble hammer-stone with evidence at both ends of well defined wear from usage which has also caused the removal of several flakes. A larger but similar water-worn pebble hammer-stone was found in the same vicinity. This specimen, much battered, was doubtless used for heavier duties.

Fig. 7. Prepared from the corner of a fine-grained pebble. It possesses a well used but distinct stepped trimmed working edge. Secondary employment as a hammer-stone is indicated by well developed pit marks upon the nether side and at its apex.

Fig. 8. Made from a small block with somewhat massive and thick but good trimming along both marginal edges. This could signify employment for heavy work. It possesses a keeled base.

Fig. 9. A thin flake with a well defined prominent bulb of percussion and very light symmetrical trimming along its edges. This has the appearance of some form of pressure flaking.

Fig. 10. An irregular lump but has neat even trimming and a thin working edge.

Fig. 11. An implement with a long trimmed marginal edge, unusually keen and sharp.

Fig. 12. A long end-scraper, of nondescript shape with a rounded trimmed edge.

Fig. 13. A small well prepared core with a keeled base.

Fig. 14. A core implement with a flat base, larger than fig. 13 but otherwise similar to it.

Fig. 15. Has the appearance of a flake-making core originally, but during its subsequent life, seems to have been converted, by means of stepped trimming into a core implement and when badly worn, finally employed as a hammer-stone or pounder, made apparent by its battered condition.

Fig. 16. A flat triangular shaped implement with a rather thick trimmed edge.

Fig. 17. Very similar in shape and design to fig. 10 but slightly smaller.

Fig. 18. A semi-discoidal implement with a strongly built trimmed edge of rounded form and considerable thickness. Two sections of this edge have become concave, probably due to considerable wear caused by much use.

Fig. 19. A small flat semi-biface implement with sections of the alternating secondary trimmed margins placed upon its two respective sides. These two sections are so placed that their total is equivalent to a completely circular working edge by simply reversing the implement.

Fig. 20. An almost rectangular specimen trimmed upon three edges.

Fig. 21. A small implement, roughly triangular in shape with an irregular keeled base, trimmed along the two margins which meet at its apex.

ROCK MATERIAL EMPLOYED

Fig. 1, 2 and 4. Inferior country quartzites which sometimes weather badly.

Fig. 3, 6, 7 and 15. Fine-grained quartzite rounded beach pebbles.

Fig. 9, 16, 18 and 20. The same material as used for fig. 3, 6, 7 and 15. Probably derived from several sources—cores, fragments or waste flakes struck off in the production of the large pebble choppers.

Fig. 5, 8, 10, 11, 12, 13, 14, 17, 19 and 21. From vein quartz rocks varying from superior milky quartz, with a good conchoidal fracture downwards to inferior types, lumpy, gritty or impure in texture.

The widely diverse qualities of quartz, as previously mentioned, control the direction and desired shapes of the flakes which are struck off them. The inferiority of finished implements derived from poor vein quartz, therefore, should not be considered as a reflection upon the skill of the native operator.

It appears to be difficult or perhaps undesirable to determine, without reservations, the use or uses to which small archaeological implements, such as these, were applied. An examination of the various finished specimens themselves, however, can offer some evidence to assist in suggesting possible tentative uses such as shape, design and perhaps most important of all—the thinness or thickness of their various working edges after final trimming has been applied; that is the amount of material available, large or small, to cope successfully with the work involved.

The following figured specimens may have been designed for the attached purposes:—

Fig. 9, 10, 11 and 17. For sawing or cutting.

Fig. 8, 12, 13, 14, 16, 18, 19, 20 and 21. For scraping and adzing.

Fig. 1, 2, 3, 4, 5 and 7. For chopping and scraping.

ACKNOWLEDGMENTS

Assistance rendered by the following is acknowledged with appreciation:—

Mr. E. Davies of Kangaroo Island for permission to carry out field work upon his property, including the lagoon referred to in this paper, for a period extending over 30 years; Miss B. K. Hubbard, South Australian Museum, for executing the drawings and sketch plan and Dr. D. W. P. Corbett, Curator of Fossils and Minerals at the same institution for identifying certain of the rocks to which reference is made.

REFERENCES

Cooper, H. M., 1943: Large stone implements from South Australia. Rec. S. Aust. Mus., Adelaide, 7(4): 343-369.

———— 1959: Large archaeological stone implements from Hallett Cove, South Australia. Trans. Roy. Soc. S. Aust., Adelaide, 82: 55-60.

———— 1960: The archaeology of Kangaroo Island, South Australia. Rec. S. Aust. Mus., Adelaide, 13(4): 481-503.

Howchin, W., 1903: Further notes on the geology of South Australia. Trans. Roy. Soc. S. Aust., Adelaide, 27: 90.

Tindale, N. B. and Maegraith, B. G., 1931: Traces of an extinct aboriginal population on Kangaroo Island. Rec. S. Aust. Mus., Adelaide, 4(3): 275-289.

NOTES ON SOME OPISTHOBRANCHS MAINLY FROM SOUTH AUSTRALIA

By ROBERT BURN*

SUMMARY

Of a collection of ten opisthobranch species (Mollusca: Gastropoda) from South Australia, three are described as new: *Haminoea maugeansis* (Atyidae), *Neodoris subaustralis* and *Aphelodoris lawsae* (Doridiidae), and one is a new record for the State: *Chromodoris tasmaniensis* Bergh, 1905 (Doridiidae). A study of the genus *Aphelodoris* Bergh, 1879, in south-eastern Australia indicates six distinct species, of which two are named, *berghi* Odhner, 1924, and *varia* (Abraham, 1877), and four are described as new: *lawsae, rossquicki, juliae* and *greeni*. According to the literature, *Aphelodoris* in Australia differs from other species of the genus in that the insemination duct between the female gland mass and the spermatheca is divided into a true *small* uterine duct and a wide terminally dilated *large* uterine duct. The spermatocyst is attached to the terminal dilation of the large uterine duct.

INTRODUCTION

Seven species of opisthobranch molluscs from the collections of the South Australian Museum were forwarded to the writer for identification by Dr. Helene Laws. Descriptions of these and three other species, all from South Australia, are presented in this research. Five species of the genus *Aphelodoris* Bergh, 1879, from New South Wales, Victoria and Tasmania are included.

This research was completed while the writer was in receipt of a grant from the Science and Industry Endowment Fund, C.S.I.R.O. The survey of the genus *Aphelodoris* is part of a comprehensive study of the Opisthobranchia of Australia being undertaken by the writer. Due acknowledgment is made also to Dr. Helene Laws, South Australian Museum, Adelaide (S.A.M.), Mrs. J. Hope Black (née Macpherson), National Museum of Victoria, Melbourne (N.M.V.), Dr. D. F. McMichael, Australian Museum, Sydney (A.M.), Mr. R. H. Green, Queen Victoria Museum, Launceston (Q.V.M.), and Mrs. Julia Greenhill, Tasmania Museum, Hobart (T.M.), for the loan of material considered in this research.

* Honorary Associate in Conchology, National Museum of Victoria, Melbourne.

SYSTEMATIC SECTION

Order Cephalaspidea

Suborder Scaphandracea

Family Atyidae

Haminoea maugeansis sp. nov.

Fig. 1-2

Haminoea tenera. Pritchard and Gatliff, 1903: 217, non *H. tenera* (A. Adams, 1850: 583; Pilsbry, 1993: 371; Angas, 1871: 98).
Haminoea tenera. May, 1921: 104; 1923: pl. 46, fig. 17.
Haminoea tenera. Cotton and Godfrey, 1933: 86.
Haminoea tenera. Macpherson and Gabriel, 1962: 243, fig. 283.

Material examined. SOUTH AUSTRALIA: Port MacDonnell, 1962, 3 specimens, G. Causer, N.M.V. reg. no. F26,134 (Holotype), F25,658 (dissected Paratype), S.A.M. reg. no. D.14868 (whole Paratype). VICTORIA: Rhyll, Flinders, Shoreham, Pt. Lonsdale, Torquay, numerous examples in the writers' collection.

Habitat. Crawling and browsing on *Zostera* and *Posidonia,* and on short brown algae on rock platforms.

Description. The shells of the type series are each 7 mm long and 5 mm broad. The shell (fig. 1) is delicate, broadly ovate but somewhat contracted above and rounded below. Apex very slightly impressed; outer lip rising above the apex, slightly rounded in the middle and narrowly rounded at the bottom of the aperture. Columella short, its edge reflected and continued over the inner lip as a thin glaze. The shell is entirely smooth except for minute growth lines parallel to the border of the shell. Dry shells are translucent yellow green.

The crawling animal is about twice the length of its shell. Live colouration is pale dull yellow body, everywhere suffused with dark grey pigment. Racemose orange pigment cells are prominent on the head and inside the shell. Preserved specimens soon lose all sign of the orange cells.

The head shield is broad anteriorly and slightly rounded, narrower and bilobate behind. Small black eyes show at the anterior third of the head. The parapodia are small and nearly meet in the middle line. Sole elongate oval, minutely notched in the front edge, with a small pyriform pedal gland in the rear middle line, sole length about two-thirds total animal length. Behind, in the sole plane, projects the tail-like epicochlear expansion. The shell mantle projects from the small end of the aperture and lies at the left posterior of the shell. In the groove on each side of the head is a narrow fleshy ridge; these are the organs of Hancock.

The brownish jaws consist of fine rods set end on, the projecting ends rounded. Radula (fig. 2) colourless, formula 24 x 6.1.6. The rhachidian has a broad base, a rather small cusp and a pair of insignificant lateral denticles. Lateral teeth 1-5 are high with large cusps, the marginal is shorter and blunt. The three brownish gastral plates each have 14 transverse ribs.

The anatomy was not investigated further.

Discussion. Angas (1871: 98) first introduced the name *H. tenera* (A. Adams, 1850: 583) into the Australian fauna when he recorded a species from the central New South Wales coastline. Whether or not the New South Wales species is correctly named does not concern us here. It is however specifically distinct from the species described above. The name *H. tenera* has been taken up in South Australia, Tasmania and Victoria for a shell of rounder shape that is smoother, more fragile and without periostracum. Consequently, the southern species is described as new.

H. maugeansis is recorded authentically from Tasmania (May, 1923), Victoria and South Australia. Its range into south Western Australia (Cotton, 1959: 404) needs to be verified.

Provisionally at least, the new species can be assigned to the section *Haloa* Pilsbry (1920: 367) which is characterized by "columella deeply concave, the reflected columellar margin crescentic, rather thick, its edge separated from the whorl by a furrow". Under more recent classifications, it belongs to the genus *Lamprohaminoea* Kuroda and Habe (1952: Habe, 1952: 150) with a smooth polished shell, green animal with many red markings, and the first lateral tooth with one cusp. Zilch (1959: 43) includes *Lamprohaminoea* and *Haloa* as subgenera in his treatment of *Haminoea*. The new species is retained in *Haminoea* until the species of this group are better known anatomically.

The specific name *maugeansis* refers to the distribution of the species throughout the Maugean cool-temperate province (Tasmania) and the adjacent Victorian and South Australian mainland coasts (Bennett and Pope, 1953).

Suborder Philinacea
Family Philinidae

Philine angasi (Crosse and Fischer)

Bullaea angasi Crosse and Fischer, 1865: 38, pl. 2, fig. 8.
Philine angasi. Cotton and Godfrey, 1933: 88, pl. 1, fig. 16.

Material examined. SOUTH AUSTRALIA: Peak Bay, Spencer Gulf, 16 February 1956, 1 specimen, Mrs. J. Hope Black, N.M.V. reg. no. F17,475.

Habitat. Burrowing just below the surface of sandy mud.

Distribution. Southern Australia, from south Western Australia to southern Queensland, littoral to 25 fathoms.

Discussion. The type locality of *P. angasi* is Spencer Gulf, South Australia. The present specimen, though topotypical, is too contracted and distorted to be examined anatomically. The radula has been figured from Victorian specimens (Maplestone, 1872: pl. 27, fig. 23) and the gastral plates from New South Wales specimens (Hedley, 1912: pl. 44, fig. 42-43).

Order NUDIBRANCHIA
Suborder DORIDACEA
Division EUDORIDACEA
Subdivision CRYPTOBRANCHIA
Family DORIDIDAE
Subfamily CHROMODORIDINAE

Hypselodoris saintvincentius Burn

Hypselodoris saintvincentius Burn, 1962B: 151, pl. 1, fig. 1-2.

Material examined. SOUTH AUSTRALIA: Reef, Christies Beach, near Adelaide, Gulf St. Vincent, 2 May 1963, 1 specimen, Dr. Helene Laws, S.A.M. reg. no. D.14869.

Habitat. Under stones at low tide.

Discussion. This is the first record of the species from the eastern side of Gulf St. Vincent. The type locality is Coobowie on the western shore.

Chromodoris tasmaniensis Bergh

Fig. 3

Chromodoris tasmaniensis Bergh, 1905: 69, pl. 5, fig. 12-15.
Glossodoris tasmaniensis. Burn, 1957: 17, pl. 2, fig. 10.
Glossodoris tasmaniensis. Burn, 1961: 56, pl. 15, fig. 4.

Material examined. SOUTH AUSTRALIA: Port MacDonnell, January 1965, 2 specimens, Mrs. and the late Mr. Ross Quick, S.A.M. reg. no. D.14870.

Habitat. Beneath stones at low tide.

Description. The two living slugs were "white with orange spots around the margins". Preserved they are purple-grey and 18 mm long.

The labial armature of the more contracted slug is brownish and composed of minute straight simple elements set end on in a wide band. The colourless radula has the formula 45 x 34.0.34. The first lateral tooth is broad and set a little way apart from the others in the half row as in Victorian slugs (Burn, 1961: 56); it has two

denticles on the inner side and three on the outer side. The other laterals are hamate with three to five denticles. The marginals are smaller.

In the genital organs (fig. 3), the ampulla (am) is rather long, the inner prostatic male duct (pr) is very long, winding and thin walled, the vas deferens is short, slender and muscular, and the penis (pe), in both specimens, sabot-shaped with a wide seminal aperture. The spermatheca (sp) is ovoid, the spermatocyst (sc) slender pyriform.

Discussion. The two slugs are identical with specimens from Victoria (Burn, 1957, 1961) in colour and radular formula and shape. They differ from the Ulverstone, Tasmania type specimen in the smaller number of branchiae, the shape of the labial elements and the radular formula. However, until Tasmanian slugs can be reliably identified with Bergh's description, it is better to conserve the name *C. tasmaniensis* for the present species and not rename it. The outstanding characteristic of the South Australian and Victorian slugs is that the first lateral tooth of the radula is set apart from the other teeth in the half row.

C. tasmaniensis is a new record for South Australia. It apparently has a wide range along the western Victorian coastline.

Subfamily Miamirinae

Ceratosoma brevicaudatum Abraham

Ceratosoma brevicaudatum Abraham, 1876: 142, pl. 8, fig. 6.
Ceratosoma brevicaudatum. Basedow and Hedley, 1905: 154, pl. 1.
Ceratosoma brevicaudatum. Cotton and Godfrey, 1933: 105, pl. 3, fig. 4.
Ceratosoma brevicaudatum. Burn, 1962B: 153.

Material examined. SOUTH AUSTRALIA: Whyalla, October 1964, 1 specimen, S.A.M. reg. no. D.14871; Pelican Lagoon, Kangaroo Island, 23 April 1953, 1 specimen, S.A.M. reg. no. D.14874; unlocalized, 2 specimens, S.A.M. reg. no. D.14877; Sir Joseph Banks Group, Spencer Gulf, 13 June 1965, 1 specimen, R. Bentley, S.A.M. reg. no. D.14881.

Habitat. Under stones and crawling in rock pools at low tide, dredged to 20 fathoms (Basedow and Hedley, 1905).

Discussion. Two synonyms of this species are *C. oblongum* Abraham (1876: 143, pl. 7, fig. 7) and *C. adelaidae* Basedow and Hedley (1905: 156, pl. 10, fig. 3-4). The former is based upon a spirit distorted specimen (O'Donoghue, 1924: 558) and the latter describes very small juvenile specimens (Burn, 1957: 18).

Subfamily Discodoridinae

Neodoris subaustralis sp. nov.

Fig. 4-6

Material examined. SOUTH AUSTRALIA: Sir Joseph Banks Group, Spencer Gulf, 13 June 1965, 1 specimen (Holotype), R. Bentley, S.A.M. reg. no. D.14876.

Habitat. Dredged (? in shallow water).

Description. The strongly curled holotype is 14 mm long and 12 mm broad; the length along the curve of the notum is about 30 mm. The preserved colour (after five months in 70% alcohol) is entirely cream with the exception of the retracted branchiae which are grey-brown.

The body (fig. 4) is convex in section, rounded in front and behind. The notum is a little wider than the foot and thick edged. The rhinophores and branchiae have no sheaths or pustular ornament around their cavities. The entire notum is covered by low pustules disposed in four longitudinal series of larger pustules, each surrounded by five or six smaller pustules, in the median area, and a wide band of very small and crowded pustules encircles the notum. Foot rounded and bilaminate anteriorly, obtusely pointed behind and extending a little way posteriorly beyond the notum. Mouth not prominent, oral tentacles an oblique grooved fold on each side.

The thickened labial cuticle is entirely smooth. The pale yellow radula (fig. 5) has the formula 38 x 40-41.0.40-41. The inner teeth are small and erect with straight cusps. The teeth gradually increase in height and cusp length to about teeth 35-37. The outer 4-5 teeth are much smaller with reduced cusps. The large ear-like expansion on the inner side of the larger teeth is very distinctive.

The anterior genital mass (fig. 6) has a small winding ampula (am) lying behind the large knotty prostate gland (pr). The vas deferens (vd) is short and straight, the unarmed penial sheath (ps)

EXPLANATION OF FIGURES

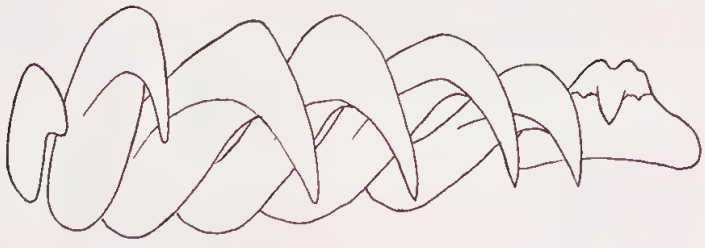
Fig. 1-2. *Haminoea maugeansis* sp. nov.
1. Ventral aspect of shell of dissected Paratype.
2. Half row of radula.

Fig. 3. *Chromodoris tasmaniensis* Bergh.
3. Anterior genital mass.

Fig. 4-6. *Neodoris subaustralis* sp. nov.
4. Dorsal view of flattened Holotype.
5. Half row of radula.
6. Anterior genital mass.

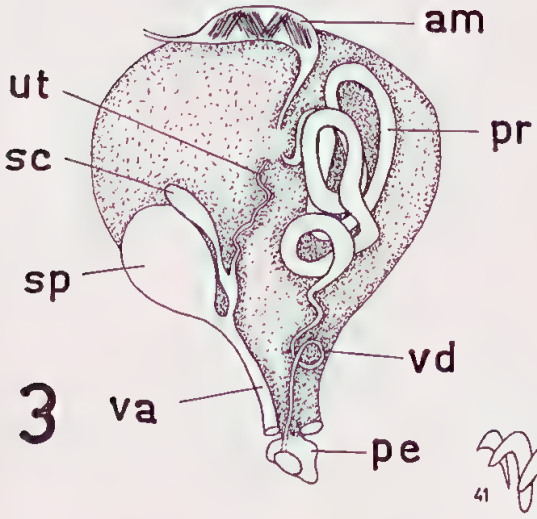
Fig. 7-9. *Aphelodoris lawsae* sp. nov.
7. Dorsal view of slug from Sir Joseph Banks Group.
8. Half row of radula.

1

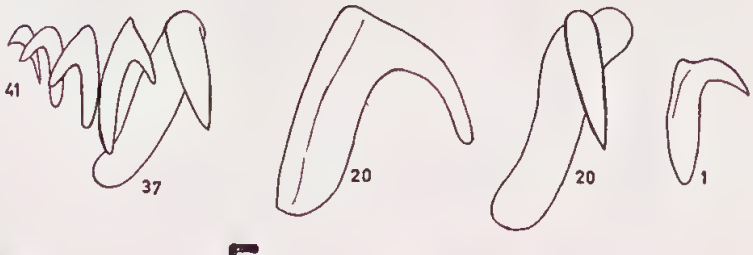


2

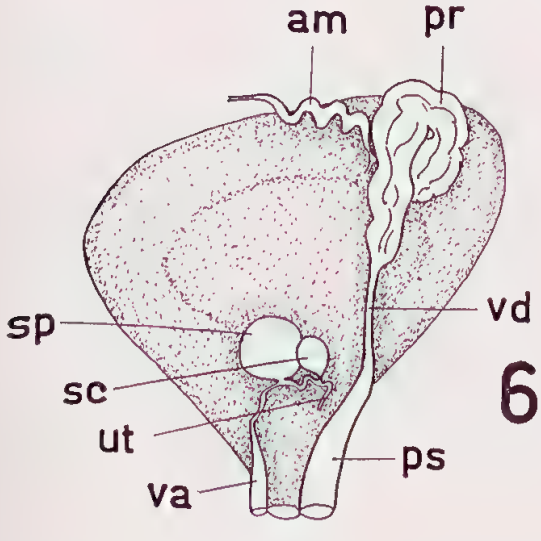
4



3

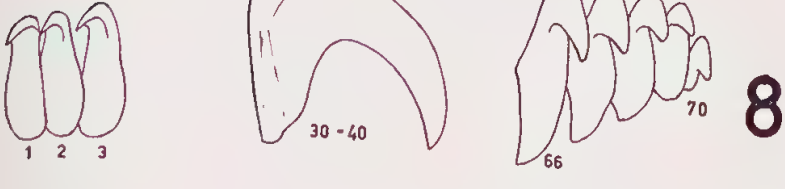


5



6

7



8

*F

Figs. 1, 2, 3, 4, 5, 6, 7, 8.

widens towards the atrium. The vagina (va) is wide at its aperture beside the penial sheath, slender thereafter. The circular spermatheca (sp) is white and attached directly to the vagina. The red-pink spermatocyst (sc) is smaller and connected by a short duct to the uterine duct (ut). The mucus gland is brick-red and encased in the yellowish albumen gland.

Discussion. N. subaustralis closely resembles *N. chrysoderma* (Angas, 1864: 46; Burn, 1957: 19, *Praegliscita*) from New South Wales and Victoria. But *N. chrysoderma* has fewer more widely spaced pustules upon the notum, 78 slender hamate teeth in the radular half row, a thinner labial cuticle and an elongate winding prostate gland.

From the literature, *N. subaustralis* is as notally pustulose as *N. tricolor* Baba (1938; 1949: 150), *N. crinacea* Marcus (1959: 38) and *N. carvi* Marcus (1959: 39). All three species have far more teeth (respectively 60-80, 75, 60-62) per radular half row than the new species with 40-41 teeth.

Subfamily HALGERDINAE

Genus **Aphelodoris** Bergh (1879: 107)

Six species* of *Aphelodoris* occur in south-eastern Australia including one species in South Australia. Four of the species are described below as new and the other two species are redescribed from fresh material.

Species of *Aphelodoris* are characterized by their "glossodoridiform" or high, slender, elongate body shape with usually narrow notal brim, smooth notum, high conical rhinophoral and branchial sheaths, laterally grooved oral tentacles, five-branched branchiae, smooth labium, hook-shaped radular teeth without denticles, unarmed penial sheath, large prostatic part in male duct, and spermatheca and spermatocyst arranged "serially" (Odhner, 1934: 270) or semiserially.

Marcus (1963: 33) found the innermost lateral tooth of the radular half row to be simply hooked in the type species, *A. antillensis* Bergh (1879: 108). Bergh, however, reported it to bear an inner denticle (1879: 111; 1880: pl. 16, fig. 13a). As simple teeth have been described in all other species attributed to the genus, it seems likely that Bergh's material had a malformed radula.

A striking feature observed in each of the six species studied for this research concerns the formation of the uterine or insemination duct of the anterior genital mass. The uterine duct comprises always two parts; an outer large diameter part with a dilated inner end to which the spermatocyst is attached, and an inner very slender part

* A seventh species, bright orange with brown streaks on the notum, was taken at San Remo, Victoria, 27 February 1966. A description will be published at a later date.

connecting the dilation of the outer, here termed *large,* uterine duct to the ampula of the hermaphrodite duct. It is supposed that the large uterine duct and in particular its dilated end serve as a fertilizing chamber. Consequently, it is supposed that the inner, here termed *small,* uterine duct is the true uterine duct.

This division into large and small uterine duct is not indicated for the type species, *A. antillensis* Bergh (1879: 113), nor in *A. brunnea* Bergh (1907: 60, pl. 12, fig. 1) and *A. luctuosa* (Cheeseman, 1882; Odhner, 1934: 270, fig. 37). Bergh (1905: pl. 5, fig. 32) shows precisely the uterine division in *A. berghi* Odhner (1924: 53; = *A. luctuosa* Bergh, 1905) but from his text it is evident that the condition was misunderstood (1905: 77).

Odhner's contention that *Aphelodoris* species have a serial connection between the vagina, spermatheca, spermatocyst and uterine duct (1934: 270; 1926: 54, Halgerdinae) cannot now be justified. Among the present six species, only *A. lawsae* and *A. rossquicki* have a true serial connection. The three species, *A. juliae, A. greeni* and *A. berghi* have the vagina and uterine duct contiguous, thereby conforming to the semiserial connection. *A. varia* has neither the vagina and uterine duct diametrically opposite (serial) nor contiguous (semiserial). Instead, they are mid-way between these two forms of connection, and indicate the development of the two other forms.

The six species discussed here are loosely divided into two groups according to the live colour pattern. The first group has lines of black or brown around the notum and forming a reticulate pattern in the median area: *A. lawsae, A. rossquicki, A. varia.* The second group has no lines on the notum but has a variable pattern of brown and maroon blotches in the median area: *A. julia, A. greeni, A. berghi.* The shape of a mid half row tooth of the radula is probably the simplest characteristic to separate the species.

A New Zealand species, *A. affinis* Eliot (1907: 343) has been reported from Western Australia by O'Donoghue (1924: 556). Absence of actual material denies its verification or otherwise, but it is highly unlikely that the species is correctly identified.

Aphelodoris lawsae sp. nov.

Fig. 7-9, 30

Archidoris varia Basedow and Hedley, 1905: 150, pl. 5; non *Doris varia* Abraham, 1877: 209.

Archidoris varia. Cotton and Godfrey, 1933: 100, pl. 2, fig. 6-7, pl. 4, fig. 11-13.

Material examined. SOUTH AUSTRALIA: Reef, Christies Beach, near Adelaide, Gulf St. Vincent, 2 May 1963, 1 specimen (Holotype), Dr. Helene Laws, S.A.M. reg. no. D.14872; 2 unlocalized specimens (Paratypes), S.A.M. reg. no. D.14873; Sir Joseph Banks Group, Spencer Gulf, 13 June 1965, 1 specimen, R. Bentley, S.A.M. reg. no. D.14880.

Habitat. Under stones at low tide, dredged (? in shallow water), to 20 fathoms (Basedow and Hedley, 1905: 150).

Description. Living slugs grow to 44 mm in length, the preserved type series is 24-29 mm long and 12 mm wide. Living colouration is generally as depicted by Basedow and Hedley (fig. 30), that is pale brown with darker brown and fawn mottles around the notal margin, over which lies a fine tracery or reticulate pattern of brown lines, and the rhinophores and branchiae purple-brown. Preserved slugs vary from pale yellow with grey patches to reddish brown with brown patches. The specimen from Sir Joseph Banks Group (fig. 7) is chocolate brown with three large pale areas in the median line, numerous varying sized rays of brown around the margin, and the whole overlaid with a fine dark brown reticulation.

The body is rather elongate and high, the notal margin is distinct and narrow, the rhinophores have high collar-like sheaths and the branchial cavity has a similar sheath. The rhinophores have 24 lamellae, the branchiae number five tripinnate plumes.

The strap-like salivary glands are short and twisted. The labial cuticle is smooth. The radular formula is 25 x 70.0.70. The inner and outer teeth (fig. 8) are high with short cusps, those in the middle of the half row are longer with long curved cusps.

The anterior genital mass (fig. 9) is as usual in the genus. Ampulla (am) long and sinuous. Prostrate gland (pr) very large, flat and thin walled, vas deferens (vd) muscular, at first slender and coiled, then wider and straight, penial sheath (ps) long, cylindrical, muscular, somewhat wider near atrium. Vagina (va) short, large uterine duct (lut) long and coiled, a little wider at its end, small uterine duct (sut) slender and straight. Spermatheca (sp) large, ovoid, spermatocyst (sc) smaller, pyriform, arranged serially. Conical genital atrium strogly muscular.

Discussion. A. lawsae is closely related to the new species, *A. rossquicki* from Victoria. Both have a reticulate pattern on the notum, in the former dark brown on chocolate brown, in the latter black on red-brown. *A. lawsae* has more, less erect and less elegant teeth in the radula, and a much shorter vagina and smaller prostate gland in the genital organs to distinguish it from *A. rossquicki.*

This species has in the past been identified with *A. varia* (Abraham, 1877: 209) from New South Wales. However, the latter species is larger, paler with a large marbled pattern on the notum, and has slender more crowded radular teeth.

The species is dedicated to Dr. Helene Laws, Curator of Marine Invertebrates, South Australian Museum, who so kindly arranged the loan of material for this paper, and who also collected the holotype.

Aphelodoris rossquicki sp. nov.

Fig. 10-11, 31

Aphelodoris varia Odhner, 1934: 270, non Abraham, 1877: 209.

Material examined. VICTORIA: Ocean Beach, Flinders, 11 April 1965, 1 specimen (Holotype), T. Crawford, N.M.V. reg. no. F25,659; 9 May 1965, 5 specimens (Paratypes), R. Burn *et al.*, N.M.V. reg. no. F26,130; Cape Patterson, 29 November 1958, 1 specimen, Mrs. Hope Black, N.M.V. reg. no. F20,112.

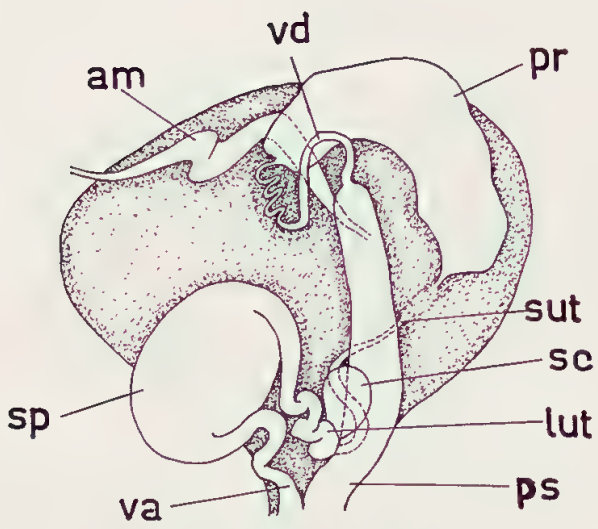
Habitat. Under stones near low tide level.

Description. The largest living slug was 35 mm long and 14 mm wide; the largest preserved one is 25 mm long and 14 mm wide. The colour pattern varies greatly; the Holotype (fig. 31) had a cream body, the notum was reddish-brown over a darker, nearly black, fine reticulation and with three irregular cream patches in the median line, and around the margin alternately red-brown and cream. The Paratypes differed regarding the amount of red-brown on the notum; some had a few small patches in the median area and one was entirely cream, in every case the black reticulation being present though even this is confined to the marginal area in some specimens. The foot is outlined in orange, the rhinophores and branchiae are purplish-brown. Preserved slugs retain much of their living colour.

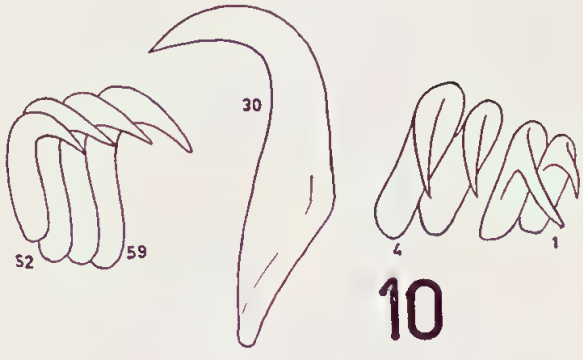
The body is rather long, soft and smooth, the notum is fairly wide and marginally undulate. The rhinophores have 18 fine lamellae and high cylindrical sheaths. The five branchiae are tripinnate, the cavity has a low sheath. The oral tentacles are as usual grooved on the outer side.

The salivary glands have broad hook-shaped ends. The labium is smooth. The radular formula is 28 x 62.0.62. The inner teeth (fig. 10) have long cusps, those of the middle half row are high with a rather short cusp, the marginals shorter with slender cusps.

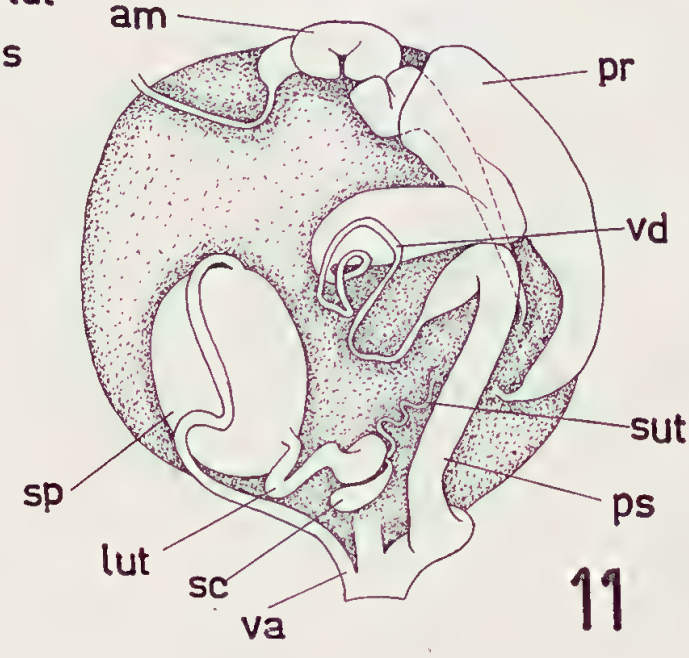
The anterior genital mass (fig. 11) has a wide twisted ampulla (am) the inner end of which is hidden behind the prostate gland. Prostate gland (pr) long and winding, vas deferens (vd) slender and muscular, penial sheath (ps) at first bent double, wider at the atrium.



9

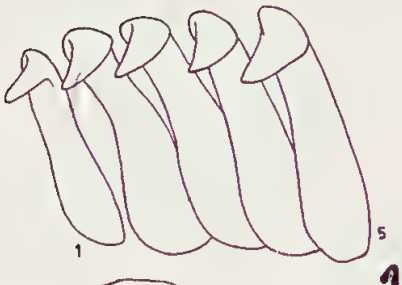


10

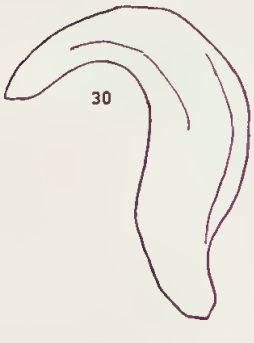


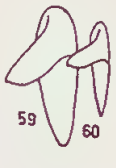
11

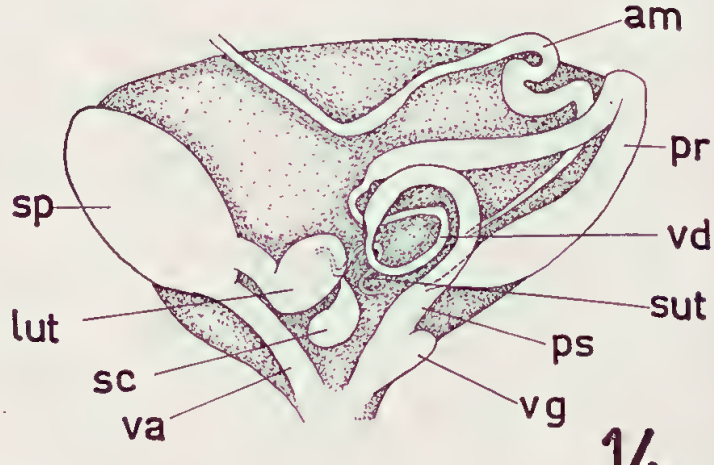
12



13







14

Figs. 9, 10, 11, 12, 13, 14.

Vas deferens and penial sheath of equal length. Vagina (va) slender and very long, entering top of large ovoid spermatheca (sp). Large uterine duct (lut) winding, dilated at inner end, small uterine duct (sut) very slender. Spermatocyst (sc) small, elongate pyriform; with spermatheca, arranged serially.

Discussion. Though similar in external appearance to *A. lawsae,* this new species differs in its prominent red-brown pigmentation over a black reticulation. Special anatomical characteristics are the elegant shape of the larger radular teeth, the exceptional length of the vagina, and the bent over first part of the penial sheath.

Odhner's *A. varia* from Victoria (1934: 270) is certainly this species. Serially connected seminal receptacles occur here and are considered diagnostic for this identification.

This species is dedicated to the memory of my late friend, Ross Quick, amateur conchologist and schoolmaster, and member of the party that collected the Paratypes.

Aphelodoris juliae sp. nov.

Fig. 12-14

Material examined. TASMANIA: Off Green Island, Simpsons Bay, Huon Channel, 21-25 July 1948, 2 specimens (Holotype and dissected Paratype), D. F. Turner, T.M. reg. no. E3587.

Habitat. Dredged in 5-7 fathoms.

Description. The larger slug is the dissected Paratype; it is 50 mm long, 28 mm wide and 15 mm high, and the sole is 12-13 mm wide for most of its length. The Holotype is strongly curled. Preserved colouration (fig. 12) consists of a creamy-orange body with large irregular sketchy patches and streaks of light maroon scattered over the notum. Around the notal margin the maroon forms alternating patches with the body colour. The foot and edges are orange, the rhinophores and branchiae black.

The body is large and rounded at each end, the notal margin is wide, very thin and undulate. The notum is entirely smooth. Rhinophoral and branchial cavities with high cylindrical sheaths.

EXPLANATION OF FIGURES (*continued*)

9. Anterior genital mass.

Fig. 10-11. *Aphelodoris rossquicki* sp. nov.

10. Half row of radula.
11. Anterior genital mass.

Fig. 12-14. *Aphelodoris juliae* sp. nov.

12. Dorsal view of flattened Holotype.
13. Half row of radula.
14. Anterior genital mass.

A pair of glands with long slender ducts and ramose ends are attached to the oral tube. The salivary glands are short and spatulate. The labium is very weak and quite smooth. The radular formula is 24 x 60.0.60; inner 12-15 teeth (fig. 13) small, slender and short cusped, those of middle large and strongly hooked, marginals short with long cusps.

Anterior genital mass (fig. 14): ampula (am) long, winding, partly hidden behind prostate gland; prostate gland (pr) very long, at first wider; vas deferens (vd) short, once coiled, muscular; penial sheath (ps) rather short and slender, at atrium with vestibular gland (vg). Vagina (va) short, spermatheca (sp) elongate oval, spermatocyst (sc) small, pyriform, arranged semiserially. Large uterine duct (lut) short, its end greatly dilated, small uterine duct (sut) very slender, winding.

Discussion. *A. juliae* is a distinctive species easily recognized by its large size and the sketchy maroon on the creamy-orange body colour. In the shape of the radular teeth, it is closest to *A. lawsae,* but the latter has an even shorter base and longer cusp. In the length of the prostate gland and penial sheath, it approaches near to *A. rossquicki,* but the greater vas deferens length in the latter, plus a far longer vagina indicate specific differences.

This species is dedicated to Mrs. Julia Greenhill, formerly Keeper in Invertebrate Zoology, Tasmanian Museum, Hobart, who so kindly forwarded a collection of opisthobranchs for study and later report.

Aphelodoris greeni sp. nov.

Fig. 15-17

Material examined. TASMANIA: Green's Beach, Kelso, Tamar River Estuary; January 1964, 1 specimen (Paratype), Q.V.M. reg. no. 1965.9.1; 29 September 1964, 1 specimen (Paratype), Q.V.M. reg. no. 1965.9.2; 11 September 1965, 1 specimen (Holotype), Q.V.M. reg. no. 1965.9.3; 30 October 1965, 10+ specimens, all collected by Mr. Robert Green and family.

Habitat. Under stones and crawling on weed in pools at low tide.

Description. The largest preserved slug is 32 mm long, the Holotype (fig. 15) is 27 mm long and 10 mm wide. The body colour is white or cream, the foot outlined with bright orange. The notal pattern consists of varying sized spots, blotches and patches of dark maroon, generally collected into three areas along the middle line. Pale brown epidermal pigment surrounds the dark maroon. The notal margin is lined alternately with dark maroon and orange. Some specimens have the maroon areas running into one another and extending nearly to the margin; others have orange pigment in place of the

pale brown. The rhinophores are blue-brown, the branchiae maroon. The maroon colour patterning persists in preservative but the orange gradually disappears.

The body is rather long, soft and smooth. The notal margin is fairly wide and undulate. The rhinophores and branchiae have prominent sheaths.

The salivary glands are long, strap-like and folded several times; in a fresh specimen they are bright pink in colour. The labium is smooth. The radular formula is 23 x 47-51.0.47-51. The inner 13 teeth have small cusps with a lateral curve, the others (fig. 16) are much larger, erect and the cusp is not greatly hooked.

Anterior genital mass (fig. 17) very small and compact. Female ducts not unlike those of *A. juliae,* but here spermatheca (sp) and spermatocyst (sc) smaller, large uterine duct (lut) longer, its dilated end much bigger. Male ducts have slenderer prostate gland (pr), much shorter penial sheath (ps) and larger vestibular gland (vg).

Discussion. A. greeni is closely related to *A. juliae* from southern Tasmania. It is distinguished externally by smaller size, narrower notal brim and intensity of colour patterning, and internally by the smaller radular formula, the erect shape of the larger teeth and details of the genital organs. The colour patterning of *A. rossquicki* is somewhat similar, but this new species lacks the black reticulation that is always present in the Victorian species.

This species is dedicated to my friend and able collector of Tasmanian opisthobranchs, Mr. Robert Green, Zoologist, Queen Victoria Museum, Launceston.

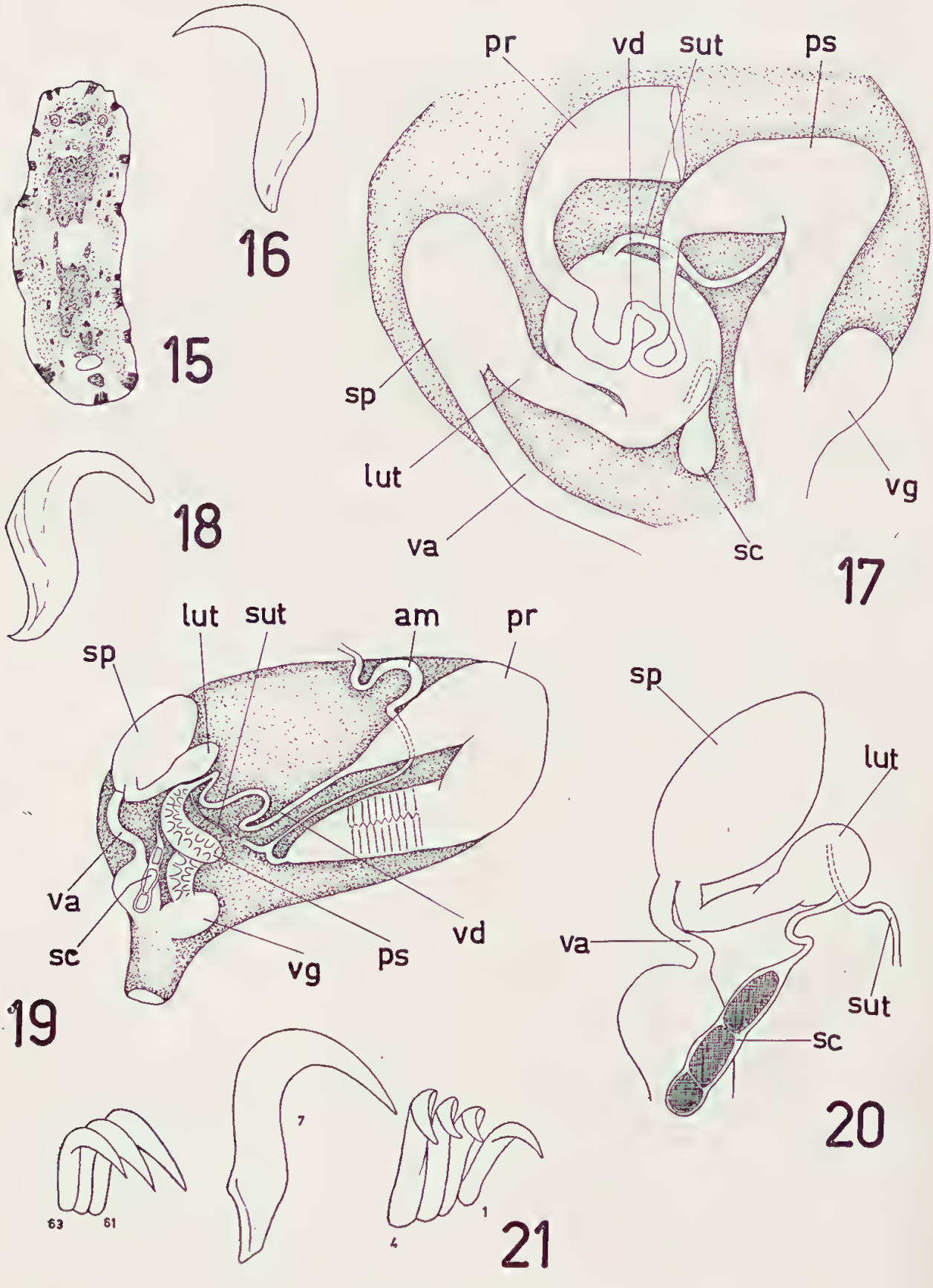
Aphelodoris berghi Odhner

Fig. 18-20, 32

Aphelodoris berghi Odhner, 1924: 53; nom. nov. pro.
Aphelodoris luctuosa Bergh, 1905: 75, pl. 5, fig. 26-32, pl. 6, fig. 1-2, non *Doris luctuosa* Cheeseman, 1882.
Aphelodoris berghi. Burn, 1962A: 102, fig. 6-7.

Material examined. VICTORIA: Off Portsea pier, Port Phillip Bay, 15 April 1962, 1 specimen, Peter Goadby, and colour slides, J. Hope Black, N.M.V. reg. no. F22,358; Point Danger, Torquay, 30 March 1959, 1 specimen, R. Burn, N.M.V. reg. no. F23,026; 10 December 1965, 4 specimens, R. Burn, N.M.V. reg. no. F26,132; reef south of San Remo, 27 February 1966, 1 specimen, R. Burn, N.M.V. reg. no. F26,133.

Habitat. Crawling on weed and stones at and below low tide level, to 4 fathoms (Portsea).



Figs. 15, 16, 17, 18, 19, 20, 21.

Description. The animal, colour and radula of this species have previously been described from Victorian slugs (Burn, 1962A). A new figure of the animal is reproduced here (fig. 32). The labium is smooth, not armed as formerly stated (*loc. cit.*: 103). The radular formula of the Portsea slug is 20 x 50.0.50; the innermost teeth have short blade-like cusps, the others (fig. 18) agree precisely with the Tasmanian figures (Bergh, 1905: pl. 5, fig. 27-28, pl. 6, fig. 1).

Anterior genital mass (fig. 19-20) very compact. Ampulla (am) two loops, little differentiated from hermaphrodite duct. Prostate gland (pr) very large, yellowish, folded in two; its cells lie in two series that meet in middle line in regular pattern. Vas deferens (vd) long, slender. Penial sheath (ps) wider and strongly coiled, outer walls muscular, smooth, inner walls raised into distinctive oval pads. Vestibular gland (vg) forms large male atrium.

Vagina (va) bursa-like at atrium, then narrower to oval spermatheca (sp). Large uterine duct (lut) shorter than vagina, inner end dilated, spherical; small uterine duct (sut) very slender, rising from rear of dilation. Spermatocyst (sc) elongate, its duct long and slender; in the Portsea specimen, spermatocyst contained three whitish masses which upon removal easily broke apart. Common genital aperture conical.

Discussion. Despite the fact that the original Tasmanian specimen was black on the back and yellowish underneath (Bergh, 1905: 75), the present material is identified with *A. berghi* Odhner (1924: 53). Radular formula and shape of the teeth agree closely as do certain features of the anterior genital mass, such as the raised pads of the penial sheath, the spherical dilation of the large uterine duct and the wide spacing of the points of attachment of the small uterine duct and the duct of the spermatocyst.

A. berghi is by its colouration alone an easily distinguished species. It is also the smallest species of the genus recorded from the Australian coastline, growing to about 30 mm in length when crawling.

It would appear that the black colour of the type specimen is of little consequence. An entirely black specimen, both externally and

EXPLANATION OF FIGURES (*continued*).

Fig. 15-17. *Aphelodoris greeni* sp. nov.

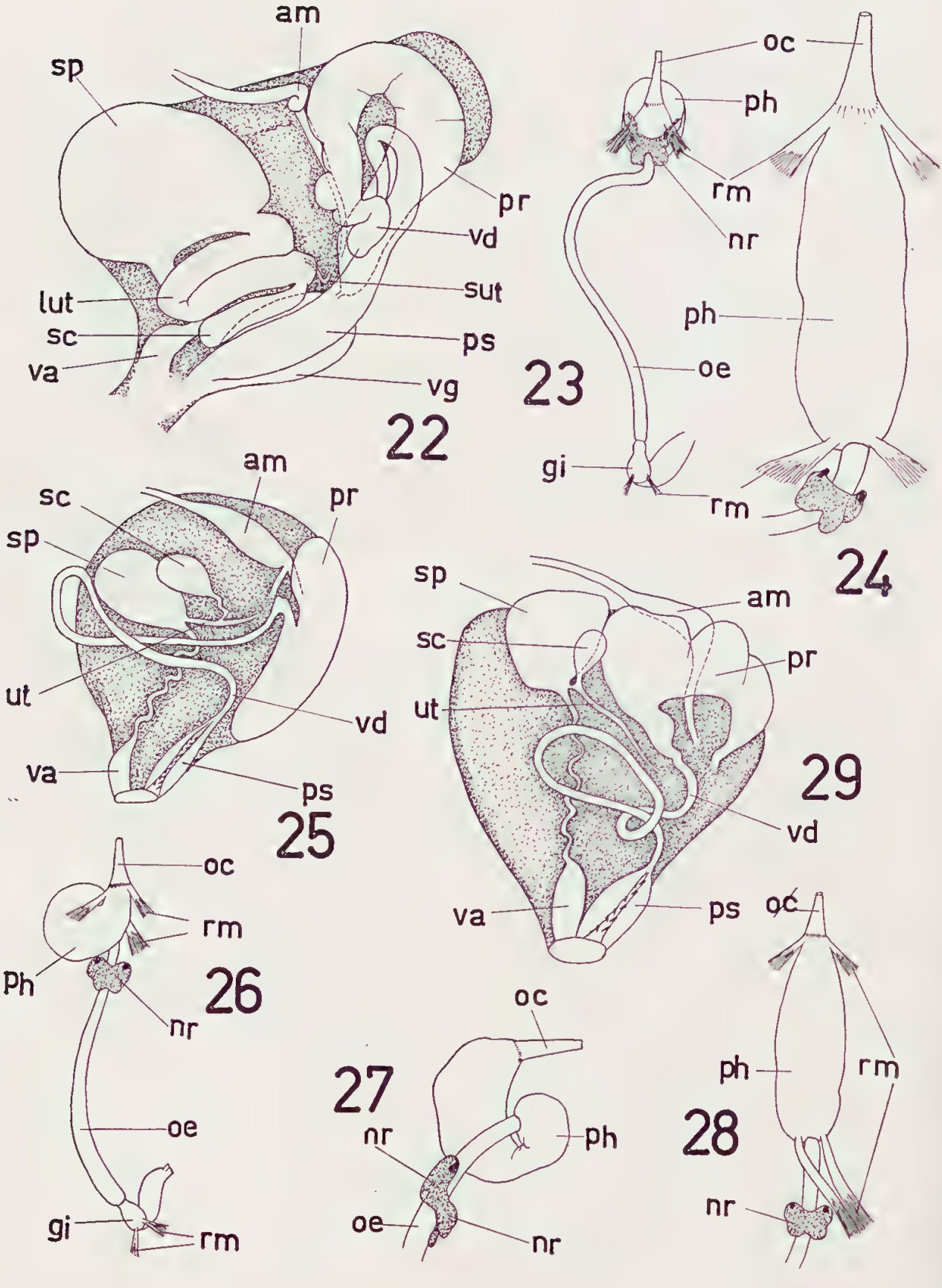
15. Dorsal view of Holotype.
16. Tooth from radular half row.
17. Female and part of male ducts, anterior genital mass.

Fig. 18-20. *Aphelodoris berghi* Odhner.

18. Tooth from radular half row.
19. Anterior genital mass.
20. Detail of female ducts.

Fig. 21-22. *Aphelodoris varia* (Abraham).

21. Half row of radula.



Figs. 22, 23, 24, 25, 26, 27, 28, 29.

internally, occurs among the specimens of *A. varia* (Abraham, 1877) examined for this research. Morphologically, the specimen is identical with others of normal cream and yellow colouration from the same general area of coastline.

Aphelodoris varia (Abraham)

Fig. 21-22, 33-34

Doris variabilis Angas, 1864: 44, pl. 4, fig. 1; non Kelaart, 1859.
Doris varia Abraham, 1877: 209.
Doris praetenera Abraham, 1877: 258, pl. 30, fig. 10-12.
Asteronotus varius. Iredale and McMichael, 1962: 93.

Material examined. NEW SOUTH WALES: Sydney Harbour, 1 specimen, J. P. Hill, A. M. reg. no. C1438 (black in colour); Pambula, 1957, 1 specimen, Mrs. T. W. Hartley, N.M.V. reg. no. F26,131; Bare Island, Botany Bay, 24 February 1961, 1 specimen and colour slide, A. Healy, A.M. reg. no. C.63086; Woody Head, Clarence River Heads, 1 May 1965, 1 specimen, Mrs. A. A. Cameron, A.M. reg. no. C.63087; 7 February 1966, 1 specimen, A. A. Cameron, A.M. reg. no. C.63088.

Habitat. Under stones and crawling on weed at low tide, to 2 fathoms on algae covered rocks (Bare Island).

Description. Crawling slugs measure at most 50 mm in length and 18 mm in breadth; a preserved slug of these live dimensions measures 34 mm long and 25 mm wide. Living slugs (fig. 33-34) have the notum yellowish white with alternates of white and brown around the margins. Immediately inside the margins lie as many as six somewhat irregular, discontinuous lines of light or dark brown. The median area is variously marbled with brown lines and small patches, rather sketchily in some specimens (fig. 33), prominently in others (fig. 34). The underside of the body is white, sometimes with small brown dots on the notal overhang. The rhinophores and branchiae are brownish-black.

The animals is rounded in front and behind. Rhinophoral and branchial cavities have high, cylindrical sheaths. The rhinophores have about 15 oblique lamellae. The branchiae consist of a single

EXPLANATION OF FIGURES (*continued*).

22. Anterior genital mass.

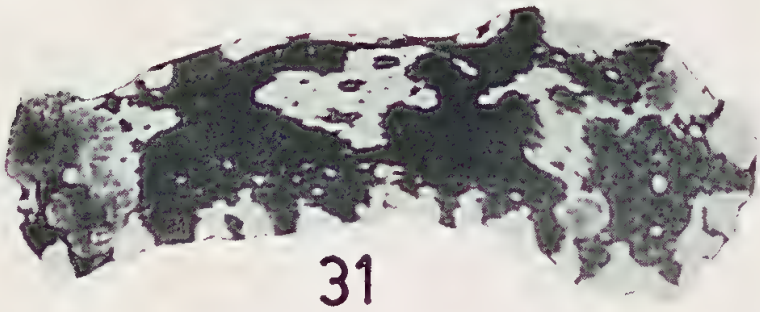
Fig. 23-25. *Doriopsilla carneola* (Angas).

23. Anterior alimentary tract.
24. Buccal mass, flattened, from above.
25. Anterior genital mass.

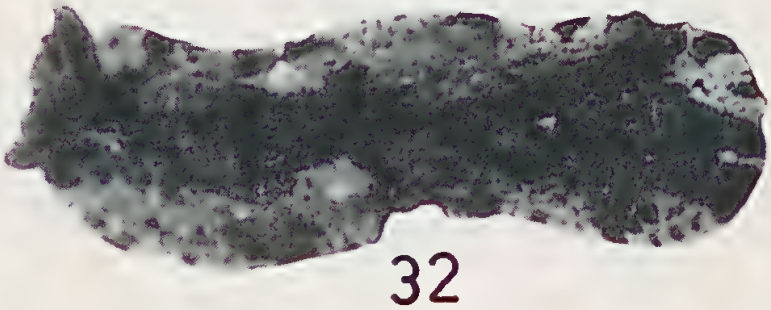
Fig. 26-29. *Doriopsilla aurea* (Quoy and Gaimard).

26. Anterior alimentary tract.
27. Buccal mass, from the right, retractor muscles not shown.
28. Buccal mass, flattened, from above.
29. Anterior genital mass.

30



31



32

33

34

Fig. 30-34.

30. *Aphelodoris lawsae* sp. nov., from Basedow and Hedley, 1905.
31. *Aphelodoris rossquicki* sp. nov., Holotype, photo. T. Crawford.
32. *Aphelodoris berghi* Odhner, Portsea Pier, photo. J. H. Black.
33. *Aphelodoris varia* (Abraham), Bare Island, photo. T. Healy.
34. *Aphelodoris varia* (Abraham), from Angas, 1864.

plume divided into a pair of laterally directed three-pronged bipinnate branchial ribs, each rimmed with short conical filiments and continuous even between each branchial rib and between each set of three ribs.

The salivary glands lie on top of the pharynx; they are flat, elongate and folded in two. The labium is usually smooth; in the Bare Island specimen, the surface was malleate and underside covered with elongate papillae. The radular formula varies from 21 x 56.0.56 to 25 x 63.0.63. The inner teeth (fig. 21) have short laterally curved cusps, those of the middle are strongly hooked and the marginals have a short base and long cusp. The teeth in each half row differ less in height from side to side and are more slender and erect than in other species of the genus.

Anterior genital mass (fig. 22); ampula (am) a brief winding of the hermaphrodite duct as it meets the genital mass; prostate gland (pr) large, bent double, at first narrower; vas deferens (vd) several short tight folds and narrow straight section; penial sheath (ps) long, wider towards atrium, vestibular gland (vg) large, sac-like. Vagina (va) short; spermatheca (sp) large, roughly circular; large uterine duct (lut) long, folded double, end little swollen; small uterine duct (sut) very short and slender; spermatocyst (sc) elongate, sausage-like.

Discussion. The encircling brown lines and the marbled patterning of the notal median area are decisive for the identification of *A. varia.* The shape of the radular teeth, the length of the large uterine duct and the sausage-like spermatocyst are also diagnostic.

A. varia is a common New South Wales species extending along the whole coastline.

Section Porostomata

Family Dendrodoridae

Dendrodoris nigra (Stimpson)

Doris nigra Stimpson, 1855: 380.

Dendrodoris nigra. Burn, 1962B: 166.

Material examined. SOUTH AUSTRALIA: American River, Kangaroo Island, 11 specimens, S.A.M. reg. no. D.14878.

Habitat. Under stones between and at low tide levels.

Distribution. Indo-Pacific, Queensland, New South Wales, Victoria, South Australia, Western Australia.

Discussion. The present preserved specimens are 30-40 mm in length, and uniform smoke-grey with paler notal margins. The species is already reported from Coobowie, St. Vincent Gulf (Burn, 1962B).

Doriopsilla carneola (Angas)

Fig. 23-25

Doris carneola Angas, 1864: 48; pl. 4, fig. 7.
Doriopsilla carneola. Burn, 1962B: 169.

Material examined. SOUTH AUSTRALIA: Sir Joseph Banks Group, Spencer Gulf, 13 June 1965, 3 specimens, R. Bentley, S.A.M. reg. no. D.14879.

Habitat. Dredged (? in shallow water) and under stones at low tide level.

Distribution. New South Wales, Victoria, Tasmania, South Australia.

Description. The largest preserved slug is 30 mm long, dull purple-red on the notum and paler on the sole. The notum is entirely granular in each specimen.

The pink pharynx (fig. 23-23, ph) is long and wide when stretched out but is thrice folded in life. Paired retractor muscles (rm) are attached to the posterior of the conical white oral cavity (oc) and the pharynx (ph). The nerve ring (nr) lies immediately behind the pharynx. The white oesophagus (oe) is long, slender and curved to the left. At its end lies a muscular cream coloured gizzard (gi) with a pair of small retractor muscles (rm).

Anterior genital mass (fig. 25); ampula (am) small, branching to male and female ducts. Prostate gland (pr) large, flat; vas deferens (vd) slender, long, looped; penial sheath (ps) short, muscular, inner walls with several spiral series of minute hooks. Vagina (va) long, very slender, winding; spermatheca (sp) large, pyriform; spermatocyst (sc) smaller; uterine duct (ut) short, straight.

Discussion. The constant red colouration of the granular notum, the position of the nerve ring immediately behind the pharynx and the large size of the prostate gland distinguish *D. carneola* from the species listed by Marcus (1961: 144-146).

Doriopsilla aurea (Quoy and Gaimard)

Fig. 26-29

Doris aurea Quoy and Gaimard, 1832: 265, pl. 19, fig. 4-7.
Doriopsilla aurea. Burn, 1962B: 168.

Material examined. SOUTH AUSTRALIA: Sir Joseph Banks Group, Spencer Gulf, 13 June 1965, 1 specimen, R. Bentley, S.A.M. reg. no. 14883; Neapean Bay, 7-14 May 1938, 1 specimen, F. Moorhouse, S.A.M. reg. no. D.14882.

Habitat. Dredged (? in shallow water); under stones at low tide level.

Distribution. New South Wales, Victoria, Tasmania, South Australia.

Description. The larger preserved specimen measures 32 mm long and 19 mm wide. The colour of both is pinkish yellow, the retracted rhinophores orange. The notum is fairly soft and pustulose, particularly near the margins.

The orange pharynx (fig. 26-28, ph) is short and fairly broad when rolled flat. In life it is curiously rolled or looped to the left side and held in place by the diverging pair of retractor muscles (rm) attached to the conical white oral cavity (oc) and the dextrally directed parallel pair of posterior pharynx retractors (rm). The nerve ring (nr) lies some distance behind the pharynx. The cream oesophagus (oe) is long and curved to the left; the muscular gizzard (gi) is pale yellow.

Anterior genital mass (fig. 29); ampulla (am) small; prostrate gland (pr) large, flat, lobate; vas deferens (vd) slender, long, looped; penial sheath (ps) short, stout, inner walls armed with hooks. Vagina (va) very slender, long, winding; spermatheca (sp) large, ovoid; spermatocyst (sc) small, pyriform, very close to spermatheca; uterine duct (ut) rather long.

Discussion. In life, the orange colouration of *D. aurea* is its chief characteristic. Of the anatomy, the rolled-up pharynx, the lobate prostate gland and the proximity of the seminal vesicles are features to separate the species from its congeners.

REFERENCES

Abraham, P. S., 1876: Notes on some Nudibranchiate Mollusca, etc. *Ann. Mag. Nat. Hist.*, (4), 18: 132-144, pl. 7-8.

——— 1877: Revision of the Anthobranchiate Nudibranchiate Mollusca, etc. *Proc. Zool. Soc. London*, 1877: 196-269, pl. 27-30.

Adams, A., 1850: *Thes. Conch.*, 2: 583, pl. 124, fig. 103.

Angas, G. F., 1864: Description d'espèces nouvelles . . . Mollusques Nudibranches . . . de Port Jackson etc. *J. Conchyliol.*, 12: 43-69, pl. 4-6.

——— 1871: A list of additional species of Marine Mollusca . . . New South Wales. *Proc. Zool. Soc. London*, 1871: 87-101.

Baba, K., 1949: *Opisthobranchia of Sagami Bay*, etc. Tokyo, 194 + 7 pp., 50 pl.

Barnard, K. H., 1927: South African Nudibranch Mollusca, etc. *Ann. S. Afr. Mus.*, 25: 171-215, pl. 19-20.

Basedow, H. and Hedley, C., 1905: South Australian Nudibranchs, etc. *Trans. Roy. Soc. S. Aust.*, 29: 134-160, pl. 1-12.

Bennett, I. and Pope, E., 1953: Intertidal Zonation of the Exposed Rocky Shores of Victoria, etc. *Aust. J. Mar. Freshw. Res.*, 4(1): 105-159, pl. 1-6.

Bergh, R., 1879: Neue Chromodoriden. *Malakozool. Bl. (N. F.)*, 1: 87-116, pl. 3.

——— 1880: On the nudibranchiate gasteropod Mollusca of the North Pacific Coast, II. *Proc. Acad. Nat. Sci. Philadelphia*, 1880: 40-127, pl. 9-16.

——— 1905: Malacologische Untersuchungen. Semper, *Reisen im Archipel der Philippenen*, 9(2): 57-115, pl. 5-8.

——— 1907: The Opisthobranchiata of South Africa. *Trans. S. Afr. Phil. Soc.*, 17(1): 1-144, pl. 1-14.

Burn, R., 1957: On some Opisthobranchia from Victoria. *J. Malac. Soc. Aust.*, 1: 11-29, pl. 1-3.

——— 1961: A new Doridid Nudibranch from Torquay. *Veliger*, 4(2): 55-56, pl. 15.

——— 1962A: Descriptions of Victorian Nudibranchiate Mollusca, etc. *Mem. Nat. Mus. Vict.*, 25: 95-128.
——— 1962B: Notes on a collection of Nudibranchia from South Australia, etc. *Ibid.*, 25: 149-172, pl. 1.
Cotton, B. C., 1959: Archaeogastropoda. *South Aust. Mollusca.* Adelaide, 449 + 2 pp., 1 pl.
Cotton, B. C. and Godfrey, F. K., 1933: South Australian Shells, 7. *S. Aust. Nat.*, 14(3): 72-108, pl. 1-4.
Crosse, H. and Fischer, P., 1865: *J. Conchyliol.*, 13: 38, pl. 2.
Eliot, C., 1907: Nudibranchs from New Zealand and the Falkland Islands. *Proc. Malac. Soc. London*, 7: 327-361, pl. 28.
Habe, T., 1952: Atyidae in Japan. *Ill. Cat. Jap. Shells*, no. 20: 137-152, pl. 20-21.
Hedley, C., 1912: Descriptions of some new or noteworthy shells etc. *Rec. Aust. Mus.*, 8(3): 131-160, pl. 40-45.
Iredale, T. and McMichael, D. F., 1962: A Reference List of the Marine Mollusca of New South Wales. *Mem. Aust. Mus.*, 11: 1-109.
Macpherson, J. H. and Gabriel, C. J., 1962: *Marine Molluscs of Victoria.* Melbourne, 475 + 15 pp., 486 figs.
Maplestone, C. M., 1872: Notes on Victorian Mollusca and their palates. *Monthly Micro. Journ.*, 1872: 45-54, pl. 25-27.
Marcus, E., 1959: Lamellariacea and Opisthobranchia. *Lunds Univ. Aarsskr. (N. F. 2)*, 55(9): 1-135.
——— 1961: Opisthobranchia from North Carolina. *J. Elisha Mitchell Sci. Soc.*, 77(2): 141-151.
Marcus, E. and E., 1962: Opisthobranchs from Florida and the Virgin Islands. *Bull. Mar. Sci. Gulf Caribb.*, 12(3): 450-488.
——— 1963: Opisthobranchs from the Lesser Antilles. *Stud. Fauna Curacao*, 19: 1-76.
May, W. L., 1921: *A Check-list of the Mollusca of Tasmania.* Hobart, 114 pp.
——— 1923: *An Illusrtated Index of Tasmanian Shells.* Hobart, 100 pp., 47 pl.
Odhner, N. H., 1924: New Zealand Mollusca. *Vidensk. Meddel. Dansk Naturh. Foren.*, 77: 1-90, pl. 1-2.
——— 1926: Die Opisthobranchien. *Further Zool. Res. Swed. Antarct. Exp. 1901-03*, 2(1): 1-100, pl. 1-3.
——— 1934: The Nudibranchiata. *Brit. Antarct. Terra Nova Exped. 1910*, Zool. 7(5): 229-309, pl. 1-3.
O'Donoghue, C. H., 1924: Report on Opisthobranchiata from the Abrolhos Islands, Western Australia, etc. *J. Linn. Soc, London*, Zool. 35, no. 237: 521-579, pl. 27-30.
Pilsbry, H. A., 1893: Tectibranchia. Tryon, *Manual of Conchology*, 15: 134-436, pl. 18-61.
——— 1920: Marine Mollusks of Hawaii. *Proc. Acad. Nat. Sci. Philadelphia*, 1920: 360-382.
Pritchard, G. B. and Gatliff, J. H., 1903: Catalogue of the Marine Shells of Victoria, 6. *Proc. Roy. Soc. Vict.*, 15 (N. S.): 176-223.
Quoy, J. and Gaimard, J., 1832: *Voyage de découvertes de l'Astrolabe*, etc. Zool. 2. Paris.
Stimpson, W., 1855: Descriptions of some of the new Marine Invertebrata from the Chinese and Japanese Seas. *Proc. Acad. Nat. Sci. Philadelphia*, 7: 378-389.
Zilch, A., 1959: Gastropoda, 2: Euthyneura. Schindewolf, *Handbuch der Paläozoologie*, 6: 12 + 834 pp.

SOMMAIRE

Dans une collection de dix espèces d'opisthobranches (Mollusca: Gastropoda) de l'Australie du Sud, on en décrit trois comme nouvelles: *Haminoea maugeansis* (Atyidae), *Neodoris subaustralis* et *Aphelodoris lawsae* (Doridídae), et l'une des autres est un nouvel enregistrement pour cet Etat: *Chromodoris tasmaniensis* Bergh, 1905 (Doridídae). Des études du genre *Aphelodoris* Bergh, 1879, dans le sud-est de l'Australie indiquent six espèces distinctes, dont deux portent déjà les noms *berghi* Odhner, 1924, et *varia* (Abraham, 1877), tandis qu'on en décrit quatre comme nouvelles: *lawsae, rossquicki, juliae* et *greeni.* Selon la litterature, *Aphelodoris* en Australie se distingue des autres espèces du genre en ce que l'oviducte entre les glandes du mucus et de l'albumine et la spermatothèque se divise dans un vrai *petit* conduit utérin et un *grand* conduit utérin qui se dilate terminalement. Le spermatocyste s'attache à cette dilation terminale du grand conduit utérin.

ABBREVIATIONS

am—ampula; gi—gizzard; lut—large uterine duct; nr—nerve ring; oc—oral cavity; oe—oesophagus; ov—oviduct; pe—penis; ph—pharynx; pr—prostate gland; ps—penial sheath; rm—retractor muscles; se—spermatocyst; sp—spermatheca; sut—small uterine duct; ut—uterine duct; va—vagina; vd—vas deferens; vg—vestibular gland.

SHORT NOTES

Editorial Note: *Short contributions are invited for this new section of our journal. Its function is to record occurrences, observations and ecological incidents which are of value, but which will not provide the substance of a formal paper. Authors will be provided with* 25 *reprints free of charge.*

THREE FISHES PREVIOUSLY UNRECORDED FROM SOUTH AUSTRALIA

Plate

During the past few years three fishes have been cast up on South Australian shores, each of which constitutes an addition to the fish fauna of the State as listed by Scott (1962).

Two of these species, *Lampris regius* and *Regalecus pacificus,* have been widely recorded from Australia and their appearance in South Australia was to be expected.

Masturus lanceolatus on the other hand had only been recorded from Western Australia (Whitley, 1948).

Family *LAMPRIDAE*

Lampris regius (Bonnaterre)

Pleuronectes regius Bonnaterre, 1788, Tabl. Encyl. Meth., Ichth.: 79 "L'Ocean" (Dumahel): France.

An adult specimen was found struggling in shallow water at Long Beach near Kingston, on the 11th December, 1963.

A cast (Reg. No. F3287) has been prepared for public display in the South Australian Museum.

Measurements: Standard length, 96.5 cm; maximum body depth, 64.5 cm; head length, 33.5 cm; eye diameter, 6.5 cm; body weight, 272.1 kgm.

Adult nematodes from the ovary and nematode cysts from the mesentary were preserved for further study.

Family *REGALECIDAE*

Regalecus pacificus Haart

Regalecus pacificus Haart, 1878, Trans. N.Z. Inst., 10, May, p. 246, pl. 7.

A partially decomposed specimen was found on the beach at Emu Bay, Kangaroo Island, on the 13th December, 1964.

The head is preserved in the South Australian Museum (Reg. No. F3314).

Measurements: Total length, 375.7 cm; maximum body depth, 25.4 cm; head length, 19.0 cm; eye diameter, 3.5 cm.

Family *MOLIDAE*

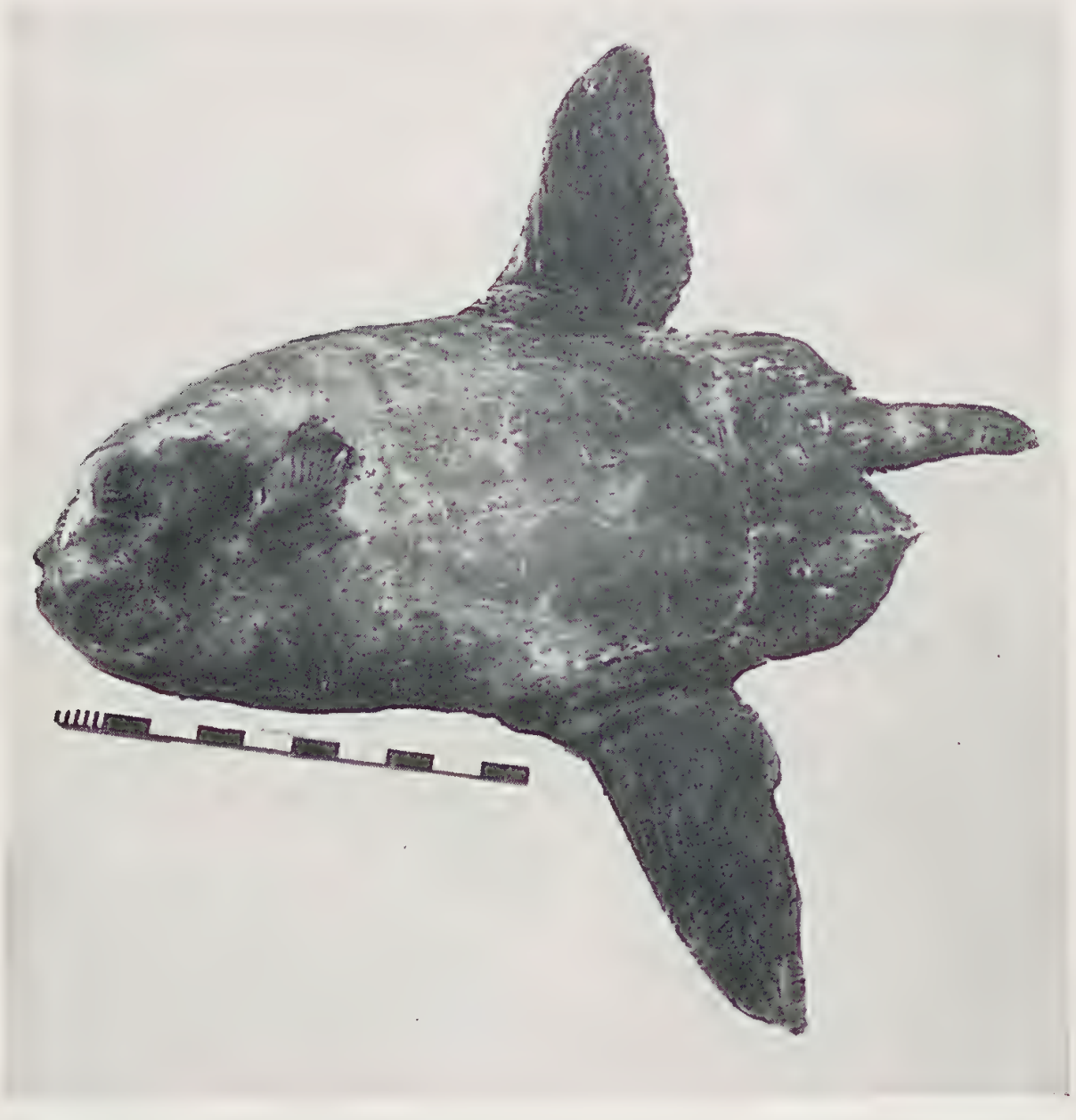
Masturus lanceolatus (Lienard)

Plate

Masturus lanceolatus Liénard, 1840, Revue Zool. Paris, pp. 291-292.

An adult female was washed ashore at Hog Bay near Penneshaw, Kangaroo Island, on the 31st July, 1965.

Portions of this specimen are preserved in the South Australian Museum including the ovary, the pharyngeal teeth, the caudal point and a section of skin.



Masturus lanceolatus (Liénard). Female, Hog Bay, Kangaroo Island, South Australia. 31st July, 1965. Scale: 1 metre rule.

Measurements: Total length, 220.9 cm; head length, 48.2 cm; eye diameter, 8.9 cm; maximum body depth, 106.6 cm; dorsal fin height, 78.7 cm; anal fin depth, 73.6 cm.

Ray Counts (estimated externally): Dorsal, 19; pectoral, 10; anal, 16; caudal, 15.

Upon dissection only a single ovary, containing a large quantity of yellow eggs, was located. The other gonad had presumably degenerated or failed to develop. This appears to be the first occasion on which the sex of a specimen of *M. lanceolatus* has been recorded.

The stomach contained no food apart from a few fragments of hydroid material.

A number of adult trematodes and cestodes were observed in the intestinal walls, and cestode larvae were found encysted in the liver.

REFERENCES CITED

Scott, Trevor D. (1962): *The Marine and Fresh Water Fishes of South Australia.* Adelaide.

Whitley, Gilbert P. (1948): A List of the Fishes of Western Australia. Fisheries Bulletin No. 2. W.A. Fisheries Department.

C. J. M. GLOVER,
Curator of Fishes, South Australian Museum.

OBSERVATIONS ON ENDOPARASITIC LEECHES INFESTING FROGS IN NEW GUINEA

Mann and Tyler (1963) reported that many frogs collected in the Central Highlands of New Guinea were hosts to endoparasitic leeches identified as a species of *Philaemon,* possibly *P. grandidieri* Blanchard. The leeches occurred subcutaneously or in the coelom, where they were found to be attached to the liver or pericardium or unattached to any structure. Faced with the evidence that some of the leeches were sufficiently large to be capable of ingesting the entire blood volume of the hosts in a single meal, they pointed out that a prolonged endoparasitic relationship would necessitate a modification of the leeches' feeding habits. Being unable to trace any scar tissue on the skins of the infested frogs they concluded that the parasites were small in size when they entered the hosts, and had remained within the hosts for a considerable period.

Since Mann and Tyler published their observations we have collected or examined a total of approximately 11,000 frogs from New Guinea, including 30 infested with leeches. It is now possible to establish the route of entry into and exit from the frogs and to determine more precisely the nature of the host-parasite relationship.

On three separate occasions leeches have been observed by one of the authors (F.P.) emerging from the cloacas of frogs and, in one instance, a leech which had emerged from a frog being carried in a collecting bag was observed to re-enter its host by the same route. Subsequent handling of the host induced the leech to emerge a second time. Whilst undertaking anthropological studies in the Kaironk Valley one of us (R.N.H.B.) was informed by the Karam people that leeches frequently emerged from the cloacas of frogs collected for food in that region and Gi of Skow, a Karam informant of R.N.H.B., has stated that he has seen leeches emerging from the cloacas of dead or dying frogs.

Examination of the cloacas of frogs from which leeches have emerged reveals small lesions on the anterior walls. The actual site of the lesion is presumed to determine whether the leech passing through the lesion will arise subcutaneously or enter the coelom.

Handling of the host by a collector is believed to directly or indirectly cause the emergence of the parasite. In the case of leeches situated subcutaneously, there would probably be direct pressure exerted upon the leech and it could even be dislodged. As the efforts of a frog attempting to escape from its captor usually include sudden and violent inflation of the lungs, it is conceivable that the resultant

changes in pressure on the contents of the thorax and abdomen could provide the stimulus for the emergence of any leeches in coelomic sites. The emergence of leeches from frogs immersed in dilute solutions of formalin has also been observed.

Emergence immediately following handling of the host by the collector can be considered premature and we are unable to find evidence to support Mann and Tyler's conclusion that the parasites have modified their feeding habits. With the possible exception of an area adjacent to the region of the scapula where the dorsal and lateral branches of the pulmo-cutaneous vessels meet, there are no major superficial sources of blood, and it seems more likely that the duration of the endoparasitic relationship is determined by the rate at which the leech ingests the blood. Whether this also applies to leeches within the coelom is not known, but unless the free-living leeches occur in extremely large numbers, the incidence of multiple infestation could be regarded as evidence to support our assumption that the ingestion of blood is a very slow process.

Free-living leeches resembling the endoparasite are known to occur in streams in the Kaironk Valley where spawn and tadpoles have been collected and infestation probably occurs there. The absence of any examples of infestation of microhylid frogs tends to support this suggestion for, with few exceptions (*e.g.*, some individuals of *Cophixalus parkeri*) Papuan species live away from water and do not migrate to water for breeding purposes. We have only one record of leeches feeding ectoparasitically on frogs in the highlands of New Guinea. We believe it to be based on the same species that occurs endoparasitically but are unable to confirm this.

The distribution of parasitised frogs is now known to extend from localities in the Star Mountains west of Telefomin to Okapa in the Eastern Highlands—a range of approximately 350 miles. The range of altitude at which our material was found is within the limits of 4,600-10,500 feet recorded by Mann & Tyler (1963). To their list of host species we can add *Hyla angiana* and *Nyctimystes papua*. Thus all of the abundant and widely distributed Hylid and Ranid species occurring in the highlands of New Guinea are known to be hosts to endoparasitic leeches.

Natives in the Sinasina, east of the Chimbu area of the highlands provided F.P. with an explanation of the endoparasitism. They believe that the frogs eat the leeches, but the constitution of the leeches is such that they are neither killed nor digested, but break their way out of the hosts' alimentary tracts and prey upon the frogs in retaliation. In the Kaironk Valley R.N.H.B. noted that

C
B
A

roasted endoparasitic leeches are considered a delicacy by women and girls. However, most men and boys will not eat them for they say that leeches eat the grease or goodness of their hosts, causing the frogs to be but skin and bone, and they fear that they would suffer a similar fate if they ate them.

REFERENCE

Mann, K. H. and Tyler, M. J., 1963: Leeches as endoparasites of frogs. Nature 197 (4873): 1224-1225.

EXPLANATION OF PLATE

Fig. 1. Parasitised specimen of *Hyla becki*. Two subcutaneous leeches are visible—a small individual on the head and a larger one attempting to escape. Prolonged distension of the skin eventually produced a lesion just above the cloaca.

Fig. 2. Leech escaping via the lesion.

Fig. 3. Host and parasite following emergence of the latter.

M. J. TYLER[1], F. PARKER[2], AND R. N. H. BULMER[3]

1 South Australian Museum.

2 Department of District Administration, Konedobu, T.P.N.G.

3 Department of Anthropology, University of Auckland, New Zealand.

Support for R.N.H.B.'s fieldwork in 1963-64 from the New Zealand University Grants Committee and U.S. Dept. of Health (M.H. 07957-01), and research facilities provided for M.J.T. by the Trustees of the South Australian Museum are gratefully acknowledged.

A BIZARRE REFUGE FOR SOME AUSTRALIAN LEPTODACTYLID FROGS

Frogs which are closely associated with man and his habitations (e.g., *Hyla caerulea*) have been collected in a wide variety of unusual locations including flower vases and beneath the lids of water closets. We are placing on record a particularly bizarre site in a suburban garden, and one which we consider might help to cast some light on the mediaeval beliefs that anurans are evil.

On 12 October, 1965, one of us (G.P.) visited a home in the Adelaide suburb of Lockleys to recover a human skeleton discovered in a shallow grave in the garden. The houses on the western side of this street are built on a North-South trending sand-dune fixed by vegetation. The Torrens River flows along the base of this dune. Such a locale as this, having fresh water, height above the plain, and in sand which was warmer to camp on than the earth of the flats, would have been favoured by aborigines for their camp-sites and, *ipso facto,* their graves. The skeleton, which subsequently proved to be of an aged female aboriginal, was buried facing east in a crouched position. The grave was 75-80 cm deep in moist orange-red sand. Excavation had commenced some days before and the skull had already been removed.

Whilst recovering the remainder of the skeleton, movement within the thorax was noticed, and removal of some of the ribs revealed the presence of three adult specimens of the Leptodactylid frog *Limnodynastes dorsalis* in the loose sand of the cavity beneath. The frogs were captured and preserved in spirits.

The stomachs and intestines of the frogs were later found to be empty, so that it is uncertain how long the specimens had sheltered in the thorax. The depth at which the skeleton was found is greater than that at which we have previously collected this species, and it seems likely that the frogs fell into the excavation rather than having burrowed down from the surface.

It is quite conceivable that the discovery of frogs in a similar situation in mediaeval times would support the opinion held then and by some primitive New Guinea tribes to this day (where corpses are exposed or buried in very shallow graves), that some frog species evolve spontaneously within human remains and are evil creatures capable of casting sickness upon people.

Nothing is known of how the Adelaide Aborigines regarded frogs other than their word for them, *ngoorto* (W. Wyatt, 1879, p. 174) and a reasonable supposition that they ate these creatures.

We gratefully acknowledge the co-operation of John Keane who notified us of his find. The skull and skeleton have been registered as No. A38994 in the South Australian Museum, and the frogs as R.6571.

REFERENCE

Wyatt, W., 1879: *Some Account of the Manners and Superstitions of the Adelaide and Encounter Bay Aboriginal Tribes*, &c. Adelaide.

GRAEME L. PRETTY AND MICHAEL J. TYLER,
SOUTH AUSTRALIAN MUSEUM, ADELAIDE.

ROCK ENGRAVINGS FROM THE ORRoroo DISTRICT, SOUTH AUSTRALIA

By H. E. BURROWS, South Australian Museum

SUMMARY

This paper refers to three rock engraving sites in the vicinity of Orroroo, Upper North of South Australia. Reference is made to the topography of the surrounding country and some of the designs, incorporated in the engravings, are described and discussed.

LOCALITY AND ITS TOPOGRAPHY

An interesting series of aboriginal rock engravings exists in the Upper Wepowie Creek, about ten miles south of Orroroo in a rock hole situated in the bed of a deep watercourse, which, when in flood, runs into the nearby main creek.

Following the Wepowie Creek downstream to the Wynflete district, there are permanent springs (Wepowie Waters). From here this gum creek runs in a north-westerly direction and finally enters Pekina Creek, a large watercourse.

The surrounding country consists of undulating hills with large areas of cultivated land. Today very few trees exist, with the exception of large gum trees farther downstream upon the banks of the main creek.

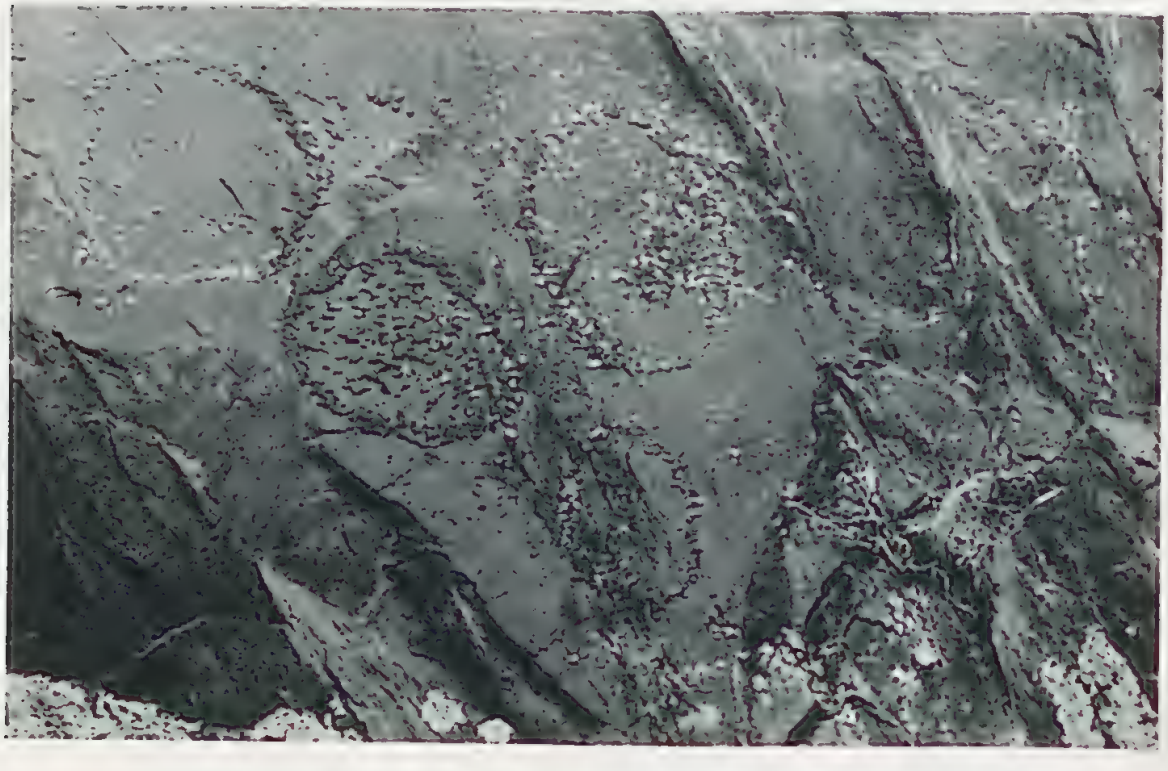
The Upper Wepowie Creek is also known to nearby property owners as Bullyacre Creek, but this is now believed to be a local name of unknown origin.

The rock engraving site is situated on a farm property owned by Mr. T. Clark at Section 22 in the Hundred of Blackrock.

The existence of the engravings was unknown during the period 1921-24 when I was employed on an adjacent property. However, in 1959, Mr. M. Cottrell (a grandson of my former employer) informed me that some years earlier he had found rock engravings which he believed to be of aboriginal origin. As far as can be ascertained they are still known only to local farmers in that area.

The writer's first visit to the Rock Hole site was in September 1959. The second visit was made a year later, with the intention of examining the engravings more closely and recording the designs. The rock hole, however, was then in a flooded condition with only the higher engravings visible, so that it was impossible to carry out the proposed work.

Fig. 1. A. South wall of Rock Hole Site—Upper Wepowie Creek.



B. Engravings on south wall of Rock Hole Site—Upper Wepowie Creek.

During March, 1965, the writer was able to photograph and also make tracings and latex moulds of this group of engravings.

A further visit was paid to the area during May, 1965. On this occasion the writer was accompanied by Mr. H. M. Cooper, Honorary Associate in Anthropology, South Australian Museum. The Upper Wepowie Creek was more closely examined and another group of engravings was discovered, about 300 yards from the Rock Hole site. We call this the Upper Wepowie site.

DESCRIPTION OF ENGRAVINGS

The designs at the Rock Hole site are executed on vertical rock faces on the north and south sides of the rock hole and the patterns are generally well defined. Others however, are barely visible owing to the smoothing effect of running water. They appear mostly to have been pecked out and the designs are chiefly conventional circles. There are also others of indefinite shapes and evidence of casual pecking marks on various parts of the rock faces. So far as could be ascertained these do not form any particular pattern or design.

Fig. 1, A, shows a general view of the south rock face at the Rock Hole site. The line of lichens above the engravings is an indication of the level to which flood waters have risen in this rock hole.

The X marks the position of a barely discernible pecked circle, the design of which finishes several inches below the present silt floor level.

Fig. 1, B, shows details of a group of engravings on the same rock face. Note the massed pecking marks within the circles and also others scattered around the group.

In the case of the Upper Wepowie site there are high rock faces on the west side of the creek at this spot, but the aboriginal artists appear not to have considered them suitable for their purpose and have recorded their art on smooth rock faces in the bed of the creek. This second series, perhaps, is more interesting than those at the Rock Hole. The main motifs again are conventional circles, but some of the designs are more complex. The engravings generally are cut deeply into the rock.

It is interesting to note that here and also at the Rock Hole there are two or three places in which portions of the engravings tend to disappear under the present bed of the watercourse. This seems to indicate that at this spot the course of the creek has silted up since the engravings were made.

Fig. 2. A. Engravings on face of rock in bed of Upper Wepowie Creek.

B. Deep engravings on face of rock in Upper Wepowie Creek.

Fig. 2, A and B, show two of the many designs upon the smooth surfaced rocks in the bed of the Upper Wepowie Creek at the second site. The designs shown in the second fig. B are deeply cut. Note the central circle with a boomerang-shaped appendage and immediately below it a straight line of well-defined peck marks.

Most of the designs in fig. 3 are from the two Wepowie sites. The exception is fig. 3, A, which is from the well known site in Pekina Creek near Orroroo. These are included for comparison with the new finds.

The designs in fig. 3, B and C, from the Upper Wepowie site seem more complex in form than those in fig. 3, D and E, from the Rock Hole site.

The broken lines of fig. 3, C, show where the design is worn and barely discernible owing to the abrasive effect of flood waters. Fig. 3, D, is a design of circles from the north wall of the Rock Hole. The broken lines at the top indicate where a water-worn gap has developed in the rock face; the remainder of the design is still intact.

The design in fig. 3, E, is also represented photographically in fig. 1, B, to assist in the interpretation of detailed drawings.

DISCUSSION

During 1915, an isolated group of rock engravings similar to those now being described, was discovered on a sloping rock of considerable size low down on Pekina Creek, near Orroroo and reported by Hosking (1926). The Pekina Creek engravings resemble those here described, consisting chiefly of plain circles, some of which are concentric. There are, in addition, several indistinct designs in pairs, believed to be representations of animal tracks.

The locations of all three of these sites is well within the area formerly occupied by the Ngadjuri Tribe (Tindale, 1940). The rock engravings at these three localities are so similar in form that it seems probable they all represent the work of members of a common tribe or group of people occupying this district. However, it is quite possible that they were not all made at one special time.

ACKNOWLEDGMENTS

The writer is much indebted to Mr. M. Cottrell for his observation and interest in locating the Rock Hole engravings and to Mr. T. Clark for the courtesy of access to the property on which the engravings were found.

Appreciation is expressed also to Mr. H. M. Cooper for the benefit of his experience and for the privilege of working under his guidance in the field.

Mr. N. B. Tindale gave encouragement and advice and my daughter, Lynona, helped in the work of recording these engravings in the field.

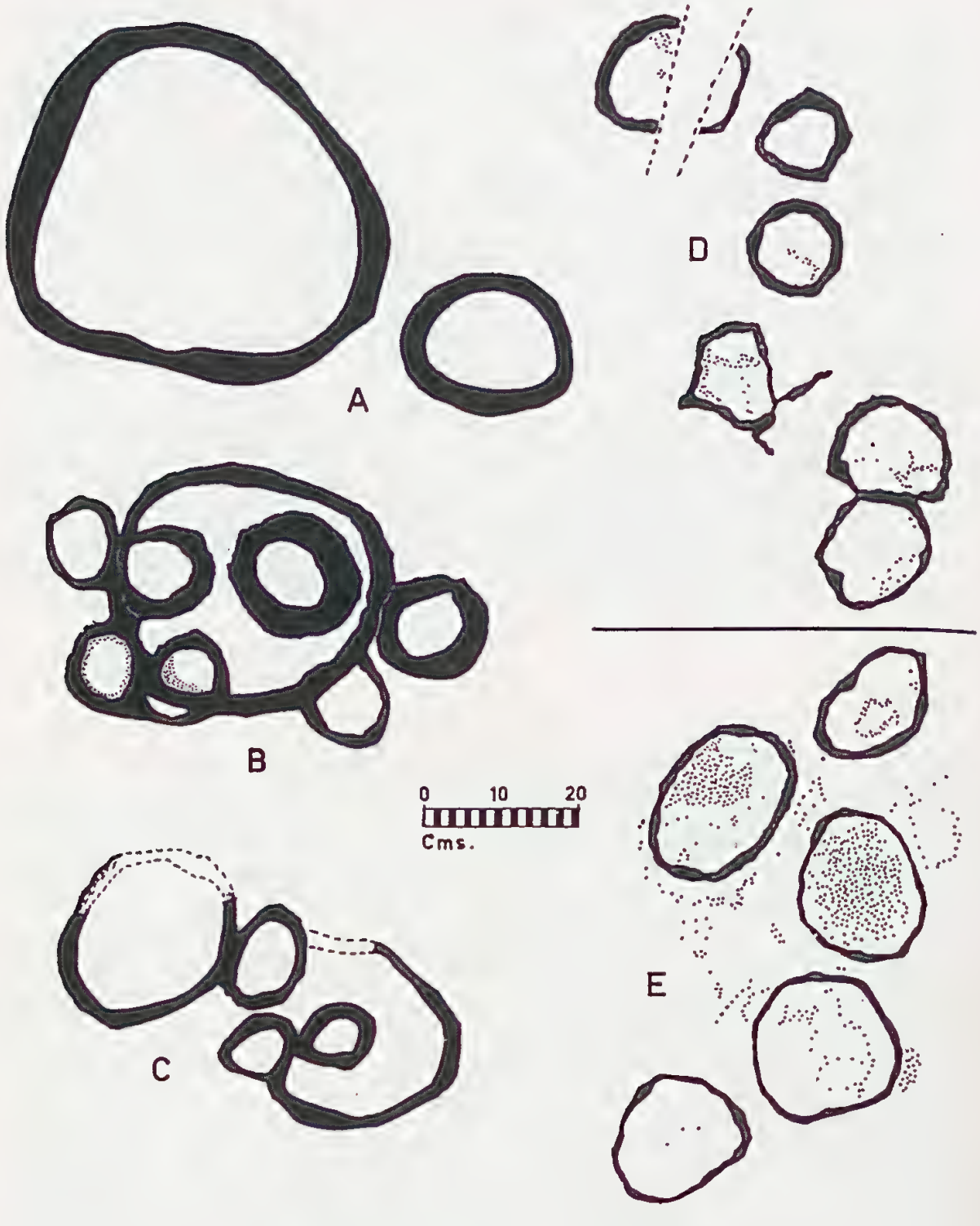


Fig. 3. A. Part of engravings on rock face in Pekina Creek.
B. C. Engravings from rocks in bed of Upper Wepowie Creek.
D. Engravings on north wall of Rock Hole Site, Upper Wepowie Creek.
E. Engravings on south wall of Rock Hole Site, Upper Wepowie Creek.

REFERENCES

Hosking, J. W., 1926: Native Rock Engravings at Pekina Creek, Orroroo, South Australia. South Aust. Naturalist, Adelaide, 8(1): p. 12 and pl. 4.

Tindale, N. B., 1940: Results of the Harvard-Adelaide Universities Anthropological Expedition, 1938-39. Trans. Roy. Soc. South Aust., Adelaide, 64(1): pp. 140-231 and map.

ABORIGINAL CAVE PAINTINGS, MOUNTAIN CREEK WATERHOLE, ST. VIDGEON, NORTHERN TERRITORY OF AUSTRALIA

By CHARLES P. MOUNTFORD and ERIC BRANDL

Mountain Creek Waterhole is situated near the old St. Vidgeon Station, south of the lower reaches of the Roper River (fig. 1).

Fig. 1. Map of Northern Australia.

The unusual group of cave paintings at this site has recently been photographed in considerable detail by one of the authors (E.B.). Later, in collaboration with the companion author, the illustrations and descriptions for this paper were prepared from the photographs.

It would seem that the paintings at the Mountain Creek Waterhole have been known for a considerable time. Tindale (personal communication) claims to have visited this site about 1922, 45 years ago, but it was not until 1957 that McCarthy in *Australia's Aborigines, their Life and Culture* (p. 159), illustrated a single figure from this cave. Later, another painting from the same locality was included in *Australian Aboriginal Art* (pl. 41, 1964, Berndt, Ed.).

The cave paintings have been found on the walls and ceiling of a tunnel in a line of cliffs, some 700 yards south-west of the Mountain Creek Waterhole (fig. 2). This tunnel is over 160 feet long, seven to 12 feet high, and averages about 25 feet wide. It is lit, somewhat

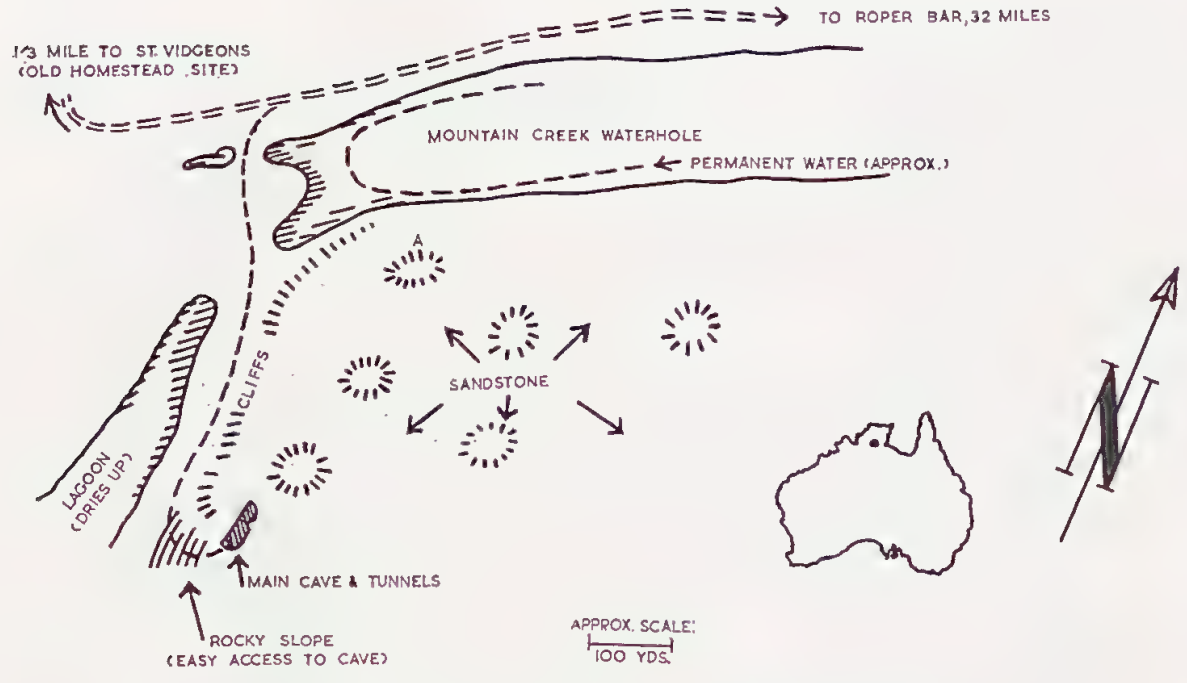


Fig. 2. Locality plan of Mountain Creek Waterhole.

dimly in places, by a number of small openings in the walls and ceilings, and by a cave, in about the centre, which has cut right through the tunnel to the back wall (fig. 3).

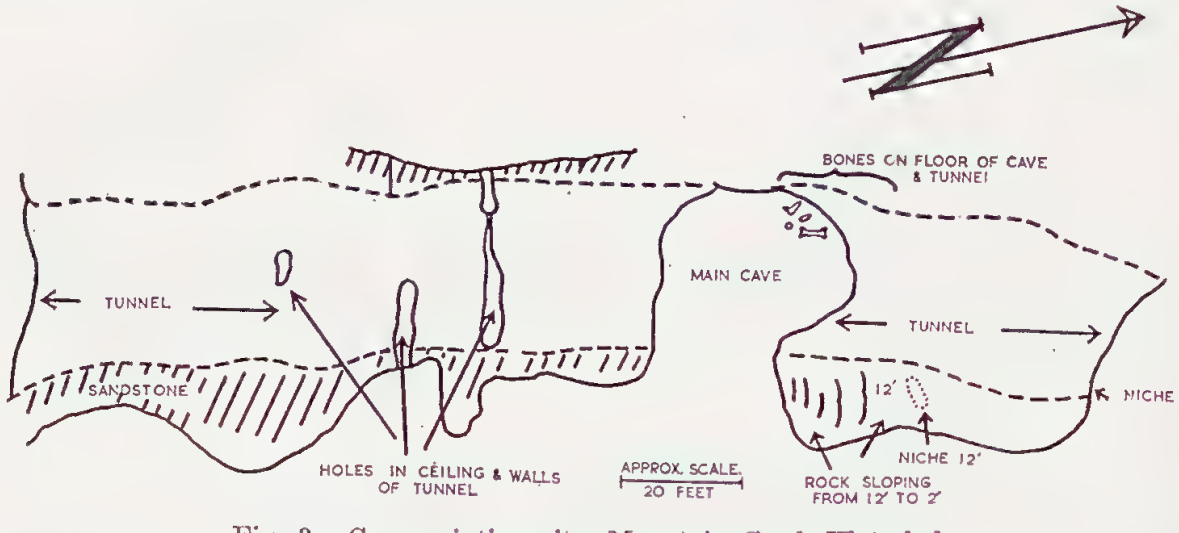


Fig. 3. Cave painting site, Mountain Creek Waterhole.

Most of the paintings are concentrated on the walls and ceilings of the cave and tunnel, although several have been found on isolated outcrops adjacent to the main site.

Many of the examples of cave art in this locality are similar to those found elsewhere in southern Arnhem Land. There are, however, a number of painted figures, for example, A, fig. 4, of which we have,

as yet, no parallels in other cave painting sites. There is little doubt, however, that further research in the adjacent country will reveal similar designs.

Fig. 4. Cave Paintings, Mountain Creek Waterhole.

Figure 4

A, represents an aboriginal, presumably a male, although the sex is not indicated[1], wearing an elaborate head-dress with horn-like projections, and decorated with lines indicating body decorations. The posture of the figure suggests that the subject of the painting is taking part in a dance.

B, although incomplete, is another equally spirited dancing figure; C is indecipherable, but the shape of the head suggests that of the spiny ant-eater, or echidna.

(1) None of the figures of this type show any sex characteristics.

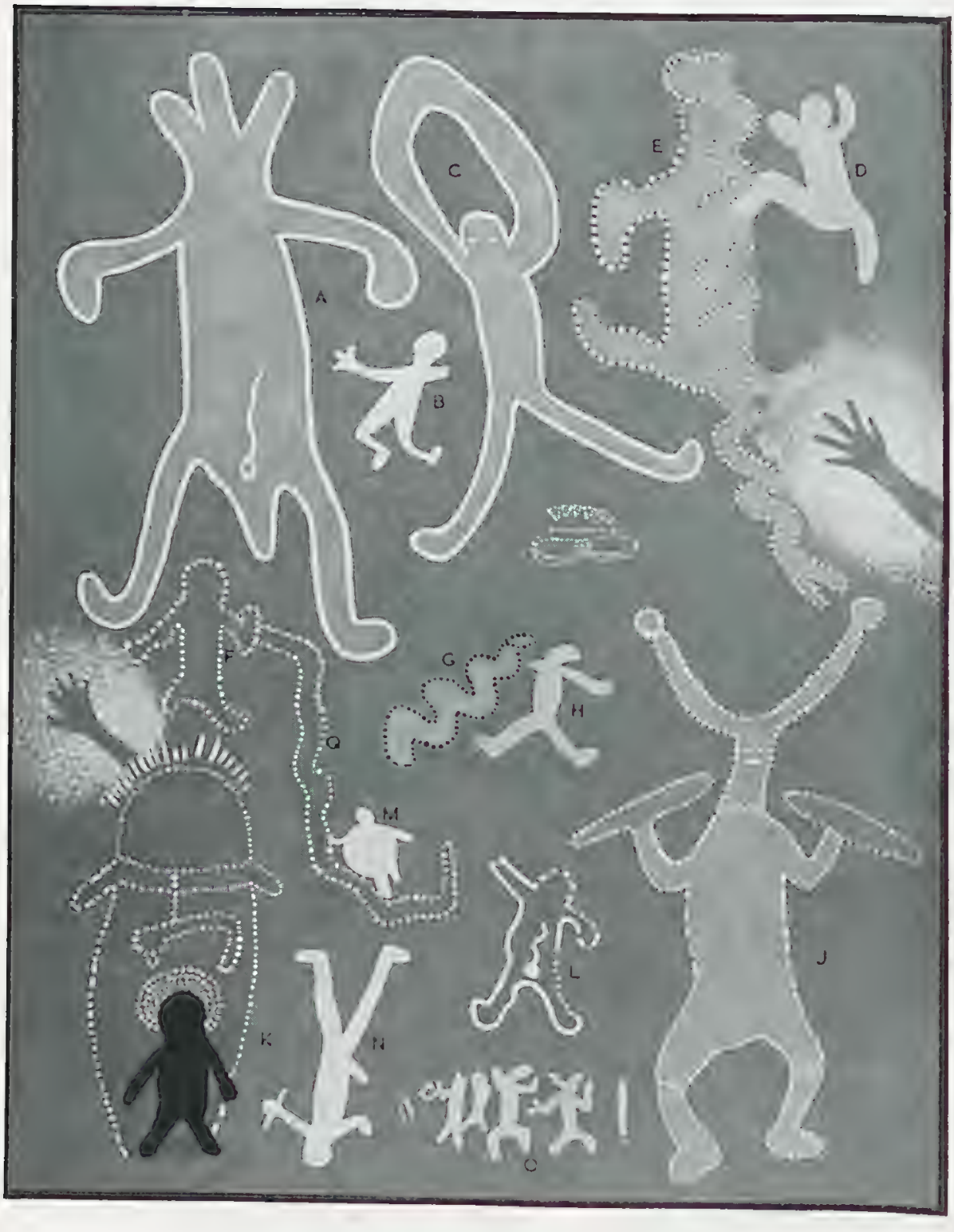


Fig. 5. Cave Paintings, Mountain Creek Waterhole.

D and E, E, are incomplete paintings of aborigines; J is an unidentified fish; K is a dancing figure, in black, which is obscured by a number of crescent-shaped designs; and R, and H, are other incomplete figures.

L, L, L, represent bird tracks, probably those of emus, and P, those of a smaller bird. M, N, and F, are dancing figures in white; the first pair are holding hands.

Scattered throughout the whole site are a number of negative hand-prints. These are made by pressing the hand against the rock-face and squirting chewed-up white pigment over it from the mouth. When the hand is removed, a negative stencil remains[2].

Figure 5

A, is a male figure wearing a form of head-dress not unlike that of A, fig. 4, and J, fig. 5, the only difference being that the body J, fig. 5, is devoid of decoration. The meandering line terminating in a circle on his abdomen, is probably a simple form of X-ray art depicting internal organs.

At B, D, H, and O, are spirited dancing figures in white; and F and L, similar designs outlined in white dots. F, is attached to a reptile-like design Q, and L has a primitive X-ray symbol on its abdomen (see A, fig. 6).

C, is a dancing figure with his hands held above his head and G, a reptilian design. E is an incomplete human figure attached to some form of reptile; M may be a representation of a sea-going turtle, and K is a wobbegong shark (*Orectolobus* sp.). A human figure in black at the bottom of K partly obscures a series of concentric circles[3] which may represent a head-dress. There is no explanation for the design immediately above the concentric circles.

J, another sexless human creature, wearing the elaborate head-dress characteristic of this locality, is carrying a shield in either hand. It is not, however, decorated on the body as is A, fig. 4, or D, fig. 8.

(2) Hand prints, both negative and positive, have a wide distribution both in Australia and in other parts of the world. In the caves of Oenpelli there are three forms of hand-prints, negative, positive (when the palm, loaded with colour, is pressed against the rock face), and negative prints decorated with abstract patterns (Mountford 1956, pl. 48).

(3) Groups of concentric circles such as these and at B, fig. 8, are a dominant motif in the art of central Australia. Nevertheless, they are uncommon, if not entirely absent, in the art of Arnhem Land. The concentric circles at this site may be the most northerly extension of this central Australian design.

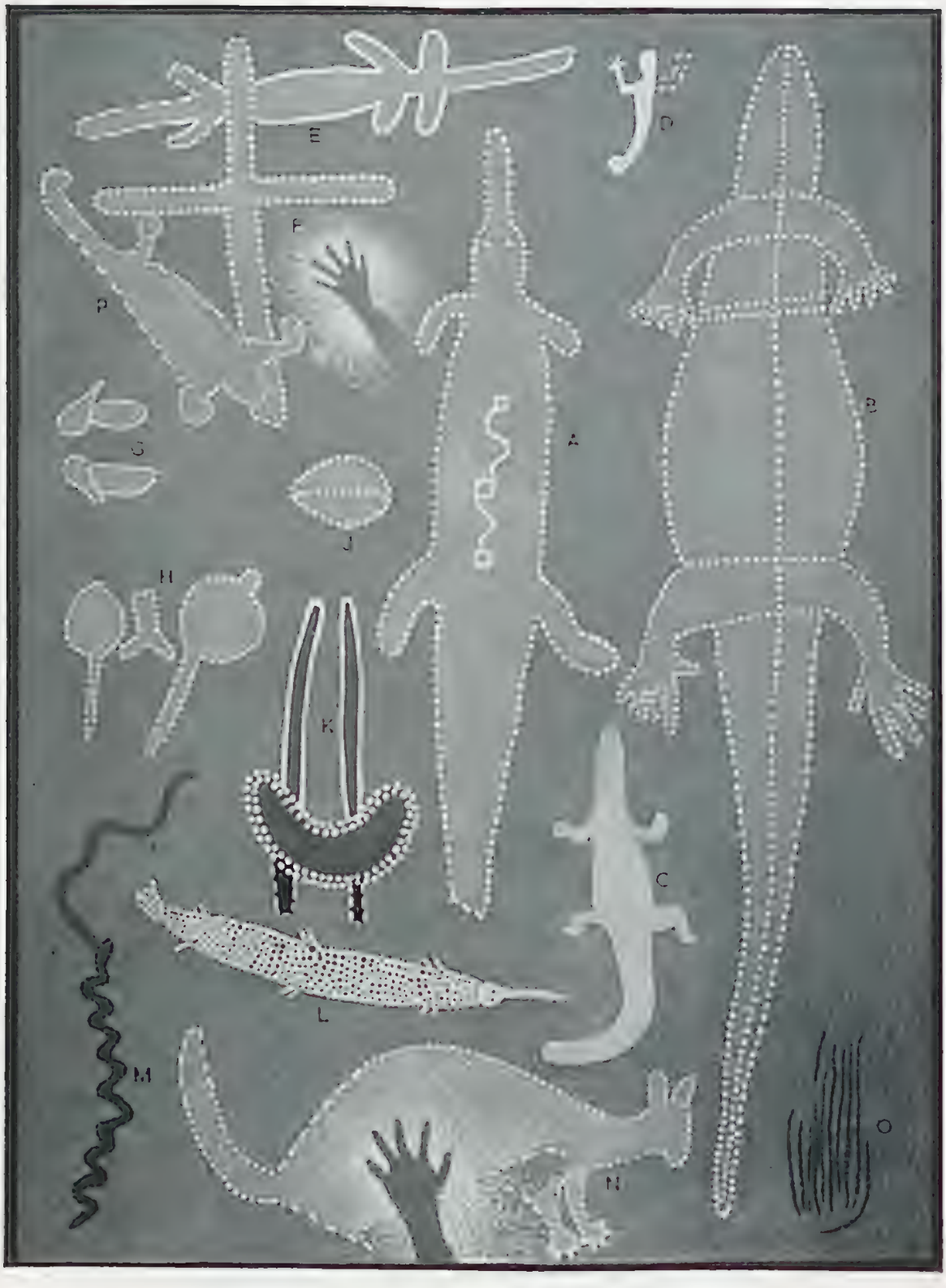


Fig. 6. Cave Paintings, Mountain Creek Waterhole.

N, is a human figure in an inverted position. Although we have no information of the meaning of this particular design, it has a wide distribution, extending from the Cape York area, where it is common, across southern Arnhem Land to Delamere (fig. 1), and probably beyond. It is almost, if not entirely absent from the cave art of both Arnhem Land and the central areas of the continent.

Figure 6

A, represents a crocodile, which, on account of the long snout, is possibly the fresh-water species (*Crocodilus johnsonii*). The meandering lines on the stomach possibly refer to the internal organs[4]. B, is an excellent representation of the sea-going crocodile (*Crocodilus porosus*), and C, possibly that of a goanna. D is an incomplete human figure with upheld arms.

E, is a distorted lizard-like creature; F, a cross-like design, an uncommon motif in Australian cave-art; P is a partly obliterated painting of a long-necked fresh-water turtle, and G is a pair of kangaroo tracks. The meaning of the oval design J, to the right is unknown.

H, probably illustrates two stingrays and the tail of a fish, the remainder having disappeared through erosion. K is an indecipherable abstract design; L, probably a garfish, M an unidentified reptile, and N a kangaroo, partly obliterated by a negative hand stencil. There is no explanation for the parallel marks at O.

Figure 7

A, is another of the typical human figures of this site, with elaborate head-dress and painted body decorations. B, is a curious male figure in black, with a tall head-dress, and large ears; C, is a simple male figure in black, while D is a snake design surrounded by a decorative pattern of white dots; E is a badly executed cave painting of a frog; F is an indecipherable painting; G, a snake design outlined with white dots, and H a dugong, dolphin, or similar mammal. J is a cave painting that strongly resembles the small water-hen which frequents the reeds at the edge of the water-courses, and K is an eagle, an identification suggested by the stance of the bird and the shape of the body.

On some of the Arnhem Land bark paintings the design L, is used to indicate yams in the ground (Mountford 1938, pls. 16 and 17).

(4) A design which appears to be characteristic of this site.

Fig. 7. Cave Paintings, Mountain Creek Waterhole.

It is likely that this design has a similar meaning. M is a badly drawn footprint, probably that of a wombat; N, N, are both indeciperable designs, and O is an unknown lizard, possibly a goanna.

Figure 8

A, is an excellent painting of an emu over a series of well-drawn concentric circles, B. This motif, as mentioned previously, is uncommon in the art of northern Australia; C, similar to K, fig. 5, is a conventionalized painting of a wobbegong shark.

D, similar to A, fig. 4, depicts an aboriginal wearing a head-dress with projecting horn-like appendages and complex body decorations, and E an unidentified fish. The two ovals on the body, similar to those on the sharks and stingrays in the bark painting art of Arnhem Land (Mountford 1956, fig. 119, B), probably represent the liver of the creature, a favourite aboriginal delicacy.

F, is a long-necked fresh-water tortoise and G, a dancing man with hands clasped over his head. This is an almost identical design to that on C, fig. 5.

H, is an armless human figure, J, two unidentified snakes, while K is a curious design which may represent one of the long-legged wading birds.

L, is an illustration of more than ordinary interest, which has been painted on an isolated outcrop at the Mountain Creek Waterhole (A, Fig. 2). In the first place it is an excellent example of a female squatting figure[5]. As far as we are aware, this design is confined to the northern coastal fringe, extending from Cape York (Mountford, 1963 unpublished data) to western Arnhem Land (Mountford, 1956, pl. 53D). This motif does not appear to have penetrated much further westward or southward. Mountain Creek Waterhole (fig. 1) is no distance from the northern coasts.

In the second place, this figure has swellings on the limbs and joints of the body. Schuster (1951) has shown that these "joint marks", with considerable variations in design, have a wide distribution over the whole Pacific area, from north-western Canada to Central America, Polynesia, Melanesia, Micronesia, Indonesia and Australia. These "joint marks" are also sparsely distributed along the northern coasts of Australia.

(5) Since writing this paper Dr. Douglas Frazer (1966, pp. 34-97) has shown that this design in its various forms which he has called "the Heraldic Woman" has been found in England, Europe, southern Italy, throughout Asia, the Pacific area, north-western Canada, central America and Peru. This paper shows that similar designs have been found on the eastern section of the northern coasts of Australia.

Fig. 8. Cave Paintings, Mountain Creek Waterhole.

M, is a female in black with greatly exaggerated ears and sex organs. The marks on the chest probably indicate body scars, while N is a small human figure in white with outstretched legs and arms.

DISCUSSION

The paintings at the Mountain Creek Waterhole are the first examples of cave art to be recorded from this part of Australia.

Most of the designs are similar to those found elsewhere in the area. Nevertheless, there are several of particular interest, for example, the widely distributed "Heraldic Women", or squatting figures; "joint marks" which have been diffused from the Pacific areas to northern Australia, and the concentric circles, a dominant motif in the art of central Australia (Mountford, 1965, fig. 9-25). Future research may show that the Mountain Creek site is one of the meeting places of three different motifs—the "joint marks" and "squatting" figures from the north, and the concentric circles from the south.

The tall, human figures, with elaborate head-dresses, highly decorated bodies, and absence of sex characteristics, appear to be confined to this site. These figures may illustrate one or another of the important mythical beings who, during the early days of the world, created some of the natural features in the surrounding country. Unfortunately there is no direct information available from the aborigines that would provide us with a clue to either the meanings of these paintings or of their place in the philosophical life of the tribe.

It was noticeable, too, that the influence of the highly elaborate X-ray art of western Arnhem Land (Mountford, 1956, pl. 39, 45, etc.), has almost expended itself at the Mountain Creek site, the only X-ray motifs that remain are meandering lines and small circles on the abdomens of certain of the men and the creatures. These probably indicate the internal organs.

The tunnel in which the paintings have been found is also a burial cave, where, at the present time, the floor is littered with human bones. It is, however, normal practice among the aborigines of this area to deposit the bones of their dead in the clefts and crevices of dry caves at the conclusion of the burial ceremonies.

SUMMARY

This paper describes a group of cave paintings at Mountain Creek Waterhole, adjacent to the St. Vidgeon Station in the Northern Territory of Australia.

The paintings are illustrated, and the motifs and distribution of the main types discussed.

ACKNOWLEDGMENTS

The authors wish to thank Mr. Hedley Brideson, the State Librarian of South Australia, for his generous assistance in providing the photographs necessary for the preparation of the illustrations for this paper.

BIBLIOGRAPHY

Berndt, R. (1964): Ed. *Australian Aboriginal Art.*

Frazer, Douglas (1966): *The Many Faces of Primitive Art.*

McCarthy, F. D. (1957): *Australian Aborigines, their Life and their Culture.*

Mountford, C. P. (1956): *Records of the American-Australian Scientific Expedition to Arnhem Land,* Vol. 1. *The Art, Myth and Symbolism.*

———— (1938): Aboriginal Decorative Art from Arnhem Land, Northern Territory of Australia. Trans. Roy. Soc. S. Aust., Vol. 63.

———— (1965): *Ayers Rock, its People, their Beliefs and their Art.*

Schuster, C. (1951): Joint Marks, a Possible Index of Cultural Contact between America, Oceania, and the Far East. Royal Tropical Institute, Amsterdam, Communication No. 44, Department of Cultural and Physcial Anthropology, No. 39.

STUDIES ON THE HAIRY-NOSED WOMBAT LASIORHINUS LATIFRONS (OWEN 1845)

I. Measurements and Taxonomy

By PETER CROWCROFT, Director, South Australian Museum

SUMMARY

The body and skull dimensions of samples of wombats (*Lasiorhinus latifrons*) mainly from Portee, Yardea and Nullarbor Stations are summarized, and some morphological differences between the populations are noted.

The type specimens of *L. latifrons, L. gillespiei* and *L. l. barnardi* are figured. It is considered advisable to regard the three forms as separate species. Although most Portee and Nullarbor specimens are readily distinguishable, no races are recognized within *L. latifrons.*

INTRODUCTION

Few specimens of the hairy-nosed, or "broad-fronted" wombat *Lasiorhinus latifrons,* apart from those retrieved from Zoological Gardens, have been preserved in museums. The Mammal Section of the British Museum (Natural History) houses the type and 13 other skulls, all except one having been acquired in the 19th century. The largest assemblage of skulls, before the present material was obtained, was in the South Australian Museum, but most of the 31 specimens lacked data on sex, size, pelage and locality.

Even fewer skins have been preserved. The British Museum (Natural History) has only two; the type of Gray's *Lasiorhinus m'coyi* (= *L. latifrons*), and a fragment mounted on wood. Stuffed specimens are to be found on display in Australian and many overseas museums, but they are useless in taxonomic work within this genus.

The present collection was made because of the planned destruction during 1963 of some hundreds of wombats on the western bank of the Murray River, between Swan Reach and Blanchetown, South Australia. While collecting on Portee Station and adjacent properties, we learned of a protracted shooting campaign against the same species on Nullarbor Station, about 800 miles to the West, and near the western extremity of the animal's range. Three expeditions to Nullarbor during 1963 and 1964 produced a sample comparable with that from the Murray River. In October, 1964, following up information from Mr. John Edkins, we sampled a large colony on the shores

of Lake Acraman, to the North of the Gawler Ranges. This provided specimens from a locality about half-way between the two extremities of the present range. Only a small number were taken, as we were averse to killing animals not under sentence. Another small sample was obtained from this area (Yardea Station) during August 1965.

The isolated pockets of this species surviving on Eyre Peninsula and Yorke Peninsula have not been sampled. A map of their distribution is being prepared by the Curator of Mammals, Mr. P. F. Aitken, and the writer.

METHODS.

The wombats were collected by shooting in the neck with a high-velocity .243 calibre rifle. Unless shot with accuracy and killed outright they are lost down their burrows. There is a slightly higher number of females than males in the shot sample. All animals were weighed and measured in the field, and the reproductive organs were fixed for later study.

The bodies were weighed to the nearest half-pound with a torsion spring balance of 100 lb. range, but because of variation in gut contents the weights have been reduced to the nearest pound. Total length was measured by laying the animal on its back upon a measuring board, with the muzzle against a vertical stop, and reading off the length at the tip of the tail to the nearest centimetre. The body was then turned over and the tail flexed and measured on its dorsal side with a steel rule. As it is difficult to position the rule exactly at the tail base, measurements to the nearest millimetre may convey a false impression of accuracy. The tail is very short relative to total length, however, and the head-and-body length has the same order of accuracy as the total length. Both have been recorded below.

The ear length was measured from the basal notch to the tip, the right ear being used unless damaged. The right hind foot measurement taken was the greatest length without the claw. Here again, there is difficulty in exactly placing the rule in position, but repeated measurements taken as a check, showed a maximum error of two millimetres, and usually less.

Fourteen measurements were taken from the skulls, but the main differences between samples can be expressed by means of the following five: A. Condylo-incisive length; B. Zygomatic breadth; C. Maxillary tooth-row length; D. Anterior nasal width; E. Maximum nasal length. Measurements B, C, and D are easily defined (fig. 1) and can be reliably taken to the nearest 0.1 mm. "A" has been taken only to the nearest 1.0 mm. because of the looseness of the incisors

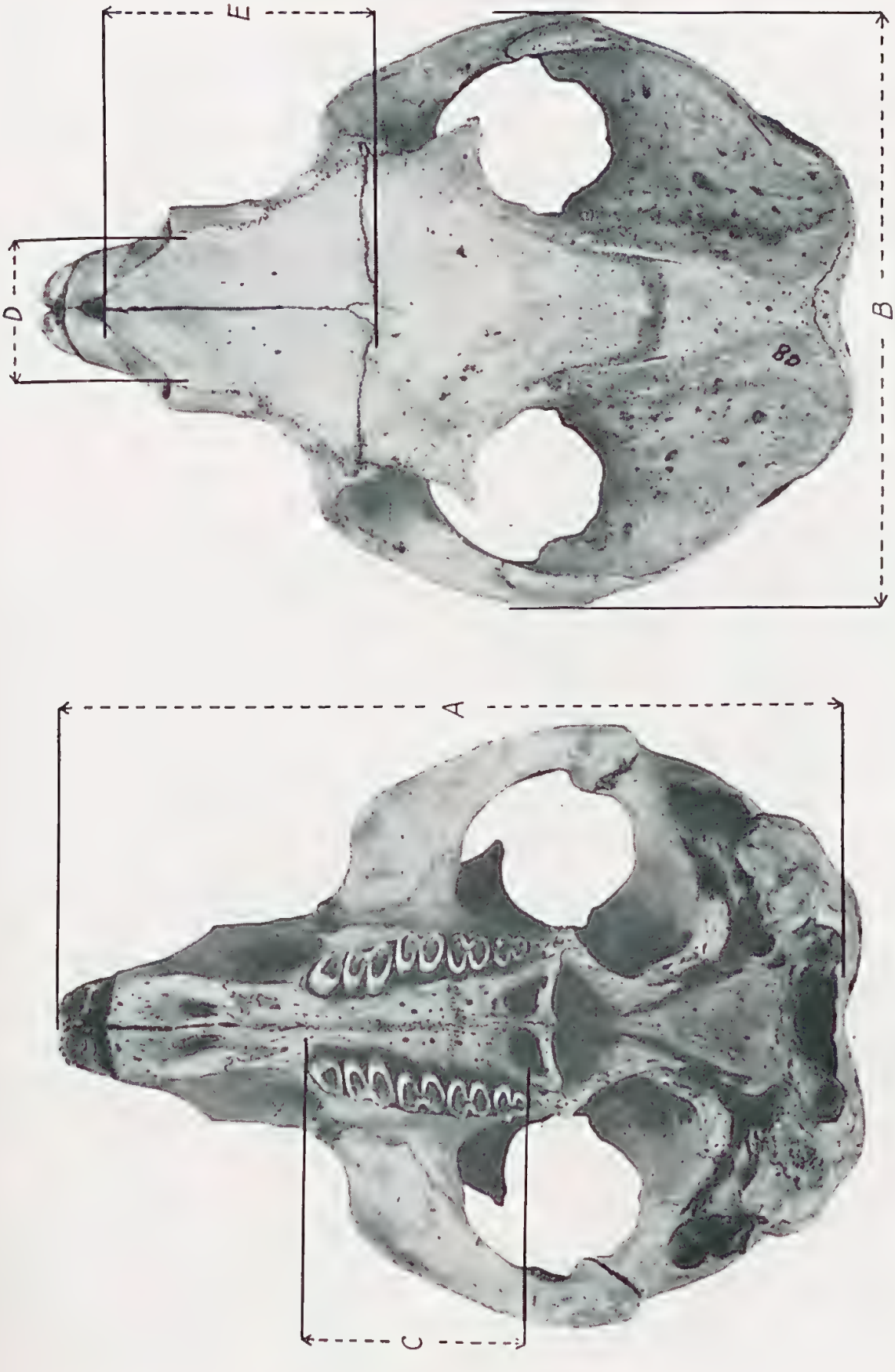


Fig. 1. The skull of a Nullarbor male, defining the principal measurements used in table 1. Maximum breadth of skull, 128.5 mm.

after skull cleaning. An alternative skull length measurement, the condylo-basal length, as defined by Thomas (1905), is difficult to obtain accurately in this species, without a specially constructed instrument. "E" can vary greatly due to the irregular and variable course of the naso-frontal sutures, and includes any projection of the nasals into the frontals.

The ages of the individuals are unknown, but only sexually mature animals are included. This eliminates all those less than three years old. A discussion of the problems of sampling has been deferred until a note is prepared upon reproduction and population dynamics. For taxonomic purposes, the present samples from Portee and Nullarbor are sufficiently representative of the populations, but the Yardea sample is rather too small.

MEASUREMENTS

The principal body measurements are summarized in table 1. There are no statistically significant differences between the sexes within each of the populations sampled, in respect of any single measurement, except in hind-foot length, in which the males are larger.

Weight. Sexual maturity is not reached or maintained at less than 40 lb. (18 kgm.), and the weight thereafter can vary enormously according to "condition". Only exceptional individuals exceed 70 lb. The significant difference between the Portee and Nullarbor weights ($P = <.01$) might not be found in samples taken in other years, but the existence of a difference of similar order in body length (see below) suggests that the weight difference is a real one. The Yardea wombats do not differ significantly in weight from those of Portee.

Length. The Portee wombats are significantly longer than those of Nullarbor ($P = <.001$ with tail; $P = <.01$ without tail). The low variances of the measurements suggest that there is little growth in length after sexual maturity is reached. The measurements of the small Yardea sample suggest greater affinity with the wombats of Portee. There appear to be more big individuals on Yardea, where there is little shooting.

It is unlikely that the Portee and Nullarbor populations differ fundamentally in age-structure. When severe drought conditions prevail, they extend over the entire range. Both populations have been under severe shooting pressure for some years, but it has been greatest upon Portee. Thus it seems safe to assume that the Nullarbor wombats are, in fact, slightly smaller at maturity than those at the eastern extremity of the animal's range.

TABLE 1

	Males			Females			Total Sample	
	N	Range	Mean ± S.E.	N	Range	Mean ± S.E.	N	Mean ± S.E.
PORTEE								
Weight ..... lb.	46	45.0–71.0	56.2 ± 0.8605	52	50.0–66.5	57.1 ± 0.5778	98	56.7 ± 0.5057
Total length .....cm.	46	84.0–98.0	90.9 ± 0.4807	53	85.0–95.0	91.8 ± 0.3428	99	91.4 ± 0.2807
Tail .....cm.	46	3.0– 6.0	4.25 ± 0.0892	53	3.0– 5.1	4.17 ± 0.0687	99	4.21 ± 0.0533
Head and body .....cm.	46	80.0–93.0	86.7 ± 0.4511	53	81.2–91.3	87.6 ± 0.3114	99	87.2 ± 0.2565
Ear .....cm.	46	8.0–10.1	8.93 ± 0.0705	53	7.9–10.0	8.98 ± 0.0724	99	8.96 ± 0.0446
Hind foot .....cm.	46	9.0–11.2	10.10 ± 0.0835	53	9.0–10.7	9.86 ± 0.0658	99	P = <.01 (t = 2.879, n = 97)
NULLARBOR								
Weight ..... lb.	42	42.0–68.0	55.4 ± 0.9697	61	42.0–69.0	53.9 ± 0.7110	103	54.5 ± 0.5886
Total length .....cm.	42	85.0–99.0	89.5 ± 0.5703	59	81.0–98.0	89.0 ± 0.4261	101	89.2 ± 0.3313
Tail .....cm.	42	2.8– 5.6	4.02 ± 0.0913	59	2.5– 5.1	3.97 ± 0.0511	101	3.99 ± 0.0479
Head and body .....cm.	42	80.8–93.4	85.6 ± 0.5260	60	77.2–93.3	85.1 ± 0.3983	102	85.3 ± 0.3206
Ear .....cm.	42	8.5–10.4	9.43 ± 0.0762	61	8.3–10.6	9.42 ± 0.0696	103	9.42 ± 0.0532
Hind foot .....cm.	42	8.3–10.4	9.44 ± 0.0914	61	8.2–10.3	9.22 ± 0.0571	103	P = <.02 (t = 2.413, n = 101)
YARDEA								
Weight ..... lb.	9	45.0–64.5	55.9 ± 2.1349	11	47.0–68.5	56.7 ± 2.1311	20	56.4 ± 1.5174
Total length .....cm.	9	86.0–97.0	91.6 ± 1.0106	11	85.0–96.0	91.3 ± 0.9821	20	91.4 ± 0.7014
Tail .....cm.	9	3.5– 5.0	4.46 ± 0.1605	11	3.5– 4.6	4.0 ± 0.1272	20	4.22 ± 0.1099
Head and body .....cm.	9	82.2–92.9	87.2 ± 0.9780	11	80.5–93.0	87.3 ± 0.9922	20	87.3 ± 0.6999
Ear .....cm.	9	8.6– 9.6	9.03 ± 0.1081	11	8.9–10.1	9.34 ± 0.1206	20	9.2 ± 0.0879
Hind foot .....cm.	9	9.4–10.7	10.10 ± 0.1277	11	9.6–10.3	9.97 ± 0.0705	20	10.03 ± 0.0679

Tail length. The wombat's tail is a vestigial organ and subject to wide variation in form and size. The variation shown is not due to the difficulty of taking the measurement; differences in tail length are sufficiently striking to be noticeable in a shot sample before measuring. The Portee measurements are only slightly, but significantly, greater than those from Nullarbor ($P = <.01$), and the Yardea sample is inseparable from the Portee.

Ear length and Hind-foot length. The Nullarbor wombats tend to have longer ears and shorter feet than those of Portee. These differences are sufficiently consistent to provide a fairly reliable diagnostic character, provided all measurements are taken by the same observer. When the ear length of the males is plotted against hind-foot length (fig. 2), there is a good separation of the two samples,

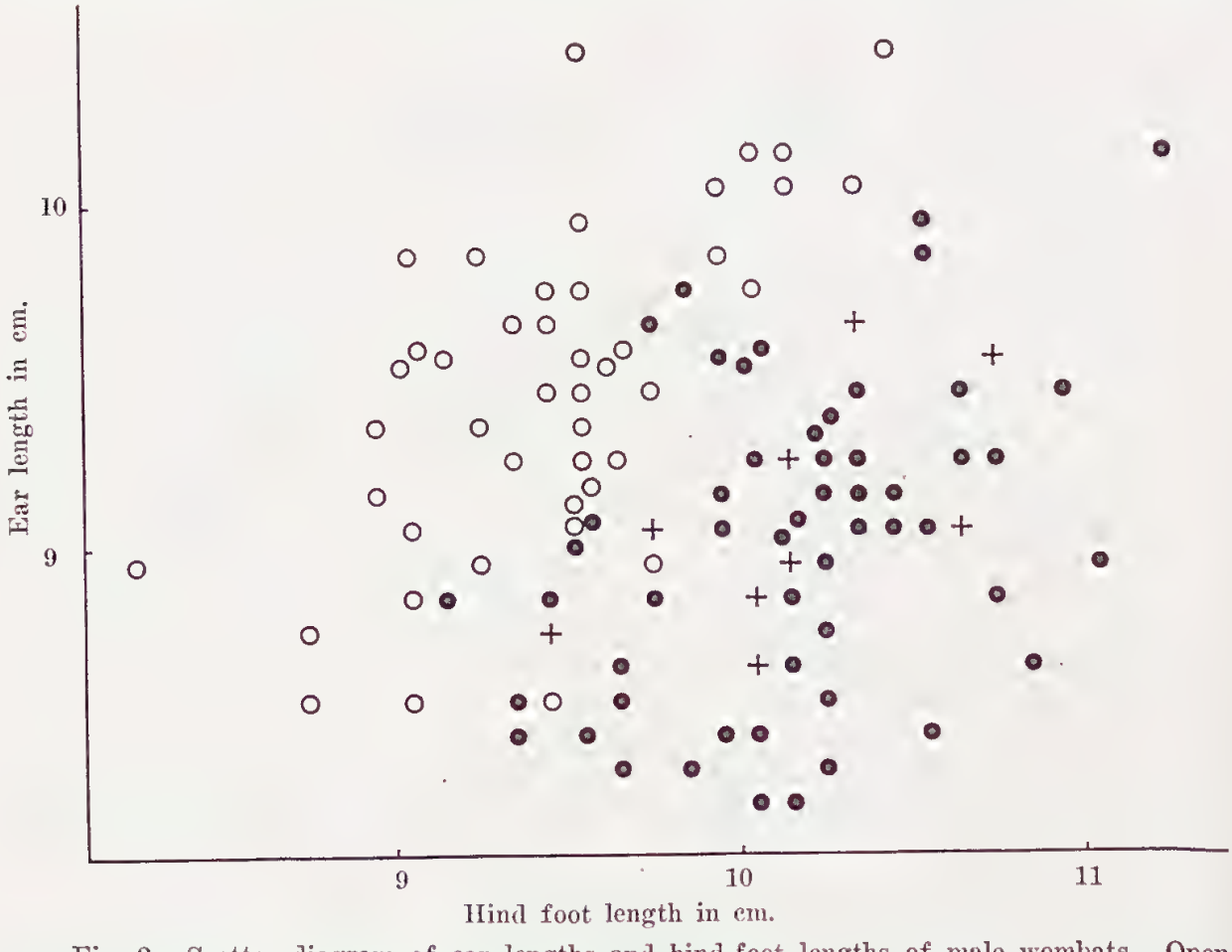


Fig. 2. Scatter diagram of ear lengths and hind-foot lengths of male wombats. Open circles, Nullarbor; closed circles, Portee; crosses, Yardea.

and when Yardea animals are added, they fall within the Portee distribution. This degree of separation applies only to males. The Portee females, having smaller hind feet, show more overlap with the Nullarbor animals in respect of the ear/hind-foot ratio.

TABLE 2

	Males			Females			Total Sample	
	N	Range	Mean ± S.E.	N	Range	Mean ± S.E.	N	Mean ± S.E.
PORTEE								
Condylo-incisive length ..	31	154.0–173.0	163.9 ± 1.1507	32	154.0.176.0	164.6 ± 1.0264	63	164.3 ± 0.6640
Zygomatic breadth	31	113.2–127.4	120.69 ± 0.6383	32	108.1–124.5	118.13 ± 0.6036		P = <.01 (t = 2.8258, n = 61)
Maxillary toothrow	31	43.5– 49.8	46.99 ± 0.2860	32	44.6– 52.2	47.69 ± 0.3148	63	47.35 ± 0.2262
Anterior nasal width	31	22.6– 30.7	25.76 ± 0.3458	32	21.2– 29.7	25.18 ± 0.3484	63	25.47 ± 0.2405
Maximum nasal length...	31	52.8– 62.5	57.26 ± 0.5792	32	52.0– 63.1	57.15 ± 0.4373	63	57.20 ± 0.3443
NULLARBOR								
Condylo-incisive length ..	36	153.0–177.0	164.2 ± 0.9612	45	150.0–172.0	161.6 ± 0.8081		P = <.05 (t = 2.0323, n = 79)
Zygomatic breadth	36	112.2–131.7	121.57 ± 0.7995	45	109.8–125.5	117.71 ± 0.5991		P = <.001 (t = 3.9225, n = 79)
Maxillary toothrow	36	43.6– 50.4	47.69 ± 0.2974	45	44.2– 50.9	47.15 ± 0.2354	81	47.39 ± 0.1878
Anterior nasal width	36	23.7– 33.2	28.62 ± 0.2082	45	23.5– 32.7	27.25 ± 0.3008		P = <.01 (t = 2.8262, n = 79)
Maximum nasal length...	36	52.0– 66.9	57.45 ± 0.5255	45	51.1– 65.0	56.96 ± 0.4104	81	57.18 ± 0.3195
YARDEA								
Condylo-incisive length ..	8	157.0–174.0	166.6 ± 2.2517	9	158.0–170.0	163.9 ± 1.1199	17	165.2 ± 1.1361
Zygomatic breadth	8	114.2–135.5	122.67 ± 2.3696	9	113.1–120.5	117.33 ± 0.9045	17	119.85 ± 1.3549
Maxillary toothrow	8	45.6– 51.9	48.62 ± 0.7331	9	43.6 –50.5	47.32 ± 0.6169	17	47.93 ± 0.5017
Anterior nasal width	8	26.5– 33.8	29.80 ± 0.7075	9	25.8– 33.7	28.21 ± 0.8290	17	28.96 ± 0.5808
Maximum nasal length...	8	53.6– 61.4	57.57 ± 0.9443	9	52.4– 61.1	54.72 ± 1.1060		P = <.05 (t = 2.2088, n =15)

Skull Size. The principal skull measurements are summarized in table 2. The skulls of females tend to be smaller than those of males, but in the Portee sample the mean condylo-incisive length is slightly greater, and the difference between the sexes is significant only in zygomatic breadth.

When the Portee and Nullarbor samples are compared (keeping the sexes separate where necessary), there are few significant differences in respect of single measurements. Those which do occur indicate a difference in skull proportions; the muzzle region is markedly broader in the Nullarbor animals. Although the nasals, which are very variable in form, show no significant difference in length, the differences in anterior breadth (defined in fig. 1) are highly significant in both sexes ($P = <.001$). A broader muzzle in the Nullarbor wombats is also indicated by the greater width across the premaxillae and greater breadth across the nostril openings. These figures are not included here, but are available with the rest of the raw data in the library of the South Australian Museum.

The Yardea wombats, contrary to expectations based upon the body measurements, resemble those of Nullarbor in skull proportions. Although their mean condylo-incisive length is only about 1.0 mm. greater than that of the Portee sample (*i.e.*, 0.5%), the anterior nasal breadth is more than 3.0 mm. greater (13.7%).

DISCUSSION

The skull of a South Australian "broad-fronted wombat" was exhibited and briefly described by Owen (1845) at a meeting of the Zoological Society of London. He named it *Phascolomys latifrons*, and gave a more detailed account, with illustrations, in the Society's Transactions (Owen, 1849). The external features of the animal were unknown, but Angas (1861) described a wombat in the Adelaide Zoo, and suggested that Owen's specimen had come from an individual of the same species.

The genus *Lasiorhinus* was erected by Gray (1863), who described *L. m'coyi* from a living wombat, also from South Australia, in the London Zoo. The same individual had previously been described by Gould (1863) as *Phascolomys lasiorhinus*. When the animal died two years later, examination of its skull showed it to belong to Owen's species (Murie 1865).

The early literature on the genera *Phascolomys* and *Lasiorhinus* has been summarized by Spencer and Kershaw (1910). Modern workers, such as Tate (1951) tend to consider the differences between the coarse-haired short-eared wombats having a hairless rhinarium,

Fig. 3. The type specimen of *Lasiorhinus latifrons* (Owen) 1945. Reproduced by permission of the Zoological Society of London. Maximum breadth of skull, 131.1 mm.

and the silky-haired long-eared wombats with a furred muzzle, to warrant generic distinction. Mohr (1942) preferred to treat *Lasiorhinus* as a sub-genus, but this seems an unnecessary complication in such a small group.

Two other modern hairy-nosed wombats have been described; *L. gillespiei* (De Vis 1900), and *L. l. barnardi* (Longman 1939), the former from southern, and the latter from central Queensland. Iredale and Troughton (1934) introduced the name *Wombatula* for *L. gillespiei,* without giving any explanation or generic diagnosis. Later, Troughton (1954) gave as his main reason for the generic rank, the striking shortening of the frontals in *gillespiei.* Tate (1951) regarded the two Queensland forms as races of *latifrons.*

The type material of the three described forms has been examined. The free projections of the nasals have been broken from Owen's type, but their original form is shown in his illustrations (Owen 1849) (fig. 3). De Vis (1900) based his description of *gillespiei* upon three skulls and two skins and did not designate a type. The sole illustration proves to be a distorted dorsal view of the skull of No. J13143 (Queensland Museum) (fig. 4) described as "a young male", whose skin is the only one extant. The type skull of the race *barnardi* (fig. 5) is also associated with the only skin known. There are three other incomplete skulls.

No further specimens of either Queensland form have been found, and inquiries have failed to produce evidence of their continued existence. The wombats taken at Deniliquin in New South Wales, and described by Kershaw (1909) were clearly the remnants of a colony of *gillespiei.* No hairy-nosed wombats now occur in the vast areas between the Queensland border and Deniliquin, or between Deniliquin and the Murray River, as far as can be ascertained.

In the absence of adequate material, the status of *gillespiei* and *barnardi* can only be assessed subjectively, having due regard for the great variability within *latifrons.*

In spite of a high degree of inherent variability in skull form, it is possible to separate Portee and Nullarbor skulls, with few errors, by means of the form of the naso-frontal sutures. The Portee skulls, like the type, frequently possess a wedge-shaped protrusion in the mid-line of the frontals into the nasals, and even when this central wedge is lacking, the sutures remain forwardly directed. In Nullarbor skulls, on the other hand, the course of the sutures runs backwards towards the mid-line, and when there is a central wedge, its base lies posterior to the lateral extremities of the sutures (figs. 1 and 6).

Fig. 4. Dorsal view of type of *L. gillespiei* De Vis 1900. Maximum breadth, 132.2 mm.

Fig. 5. Dorsal view of type of *L. ~~gilleopici~~ barnardi* (Longman) ~~1930.~~ 1939 Maximum breadth, 155 mm.

This ability to separate the two populations, added to the morphological differences already noted, would justify placing the Nullarbor wombats in a separate race, if it were not for our knowledge of the Yardea population. In these, the naso-frontal sutures tend to take an irregular but transverse course, at right-angles to the mid-line (fig. 6). This variation was also noted by Owen (1872) in one specimen, probably from Port Lincoln. Nasals of the Yardea type occur rarely in both Portee and Nullarbor samples.

A more detailed analysis of the morphological variability within these three samples would undoubtedly confirm that they are from populations in the process of divergence into distinguishable races. Although agricultural and pastoral development has drastically changed the pattern of distribution of hairy-nosed wombats, it seems highly likely that the main populations were genetically isolated before European settlement. More intensive study of these and other colonies will probably reveal a tendency to local differentiation similar to that in the North American pocket-gophers.

The naso-frontal sutures take a highly convoluted course in *gillespiei* (fig. 4), and it is similar in all known skulls. This kind of convolution is only rarely suggested in *latifrons* (fig. 6, c). *L. l. barnardi* is remarkable mainly for its massive skull, which gives the impression of great age.

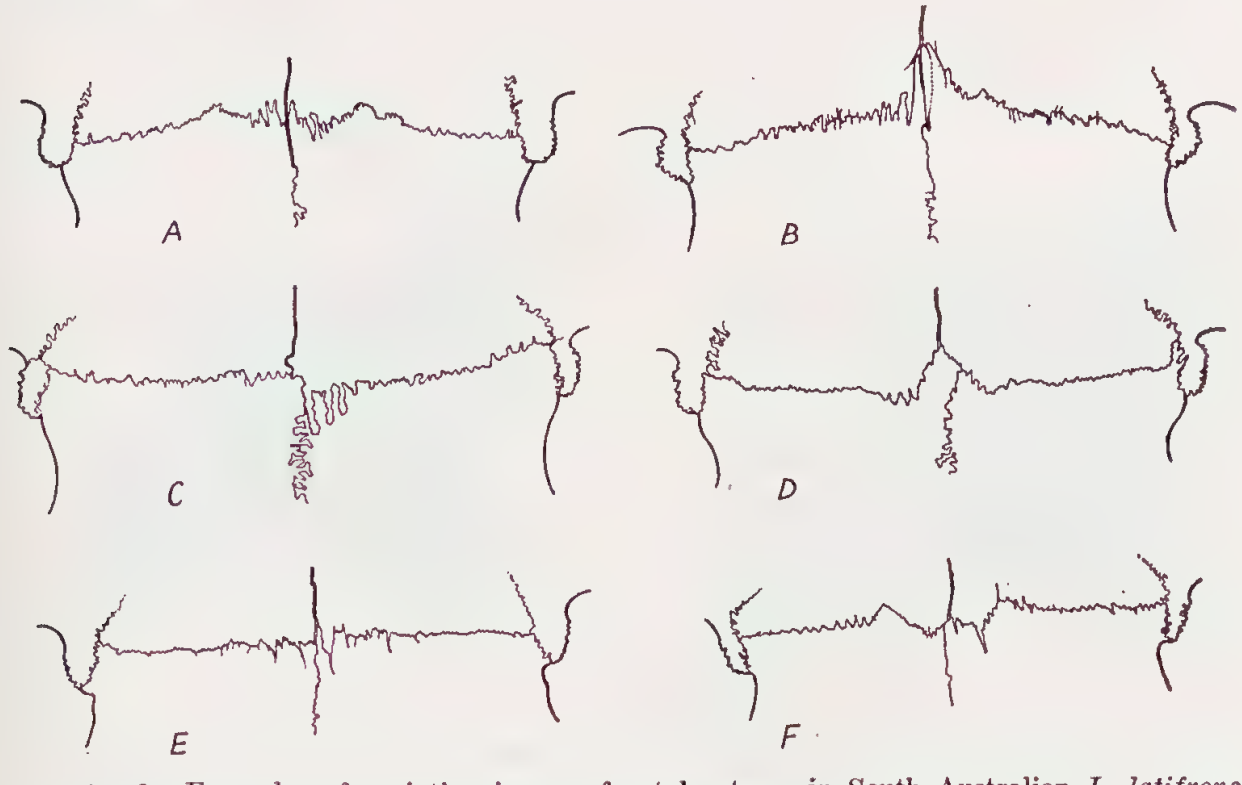


Fig. 6. Examples of variation in naso-frontal sutures in South Australian *L. latifrons*. A-B, Portee males; C-D, Nullarbor males; E-F, Yardea males.

In spite of the striking size difference between *gillespiei* and *barnardi,* the two forms exhibit common features in skull proportion which set them apart from *latifrons.* The distinctive muzzle region is best exhibited in lateral view (fig. 7). The greater forward projection of the nasals and their downward flexure, together with less obvious differences in the maxillary region, distinguish the Queensland forms (including the Deniliquin skulls) from the South Australian species. In addition, their nasals are always longer than the frontals, measured in the mid-line, while the nasals of *latifrons* are always shorter than the frontals.

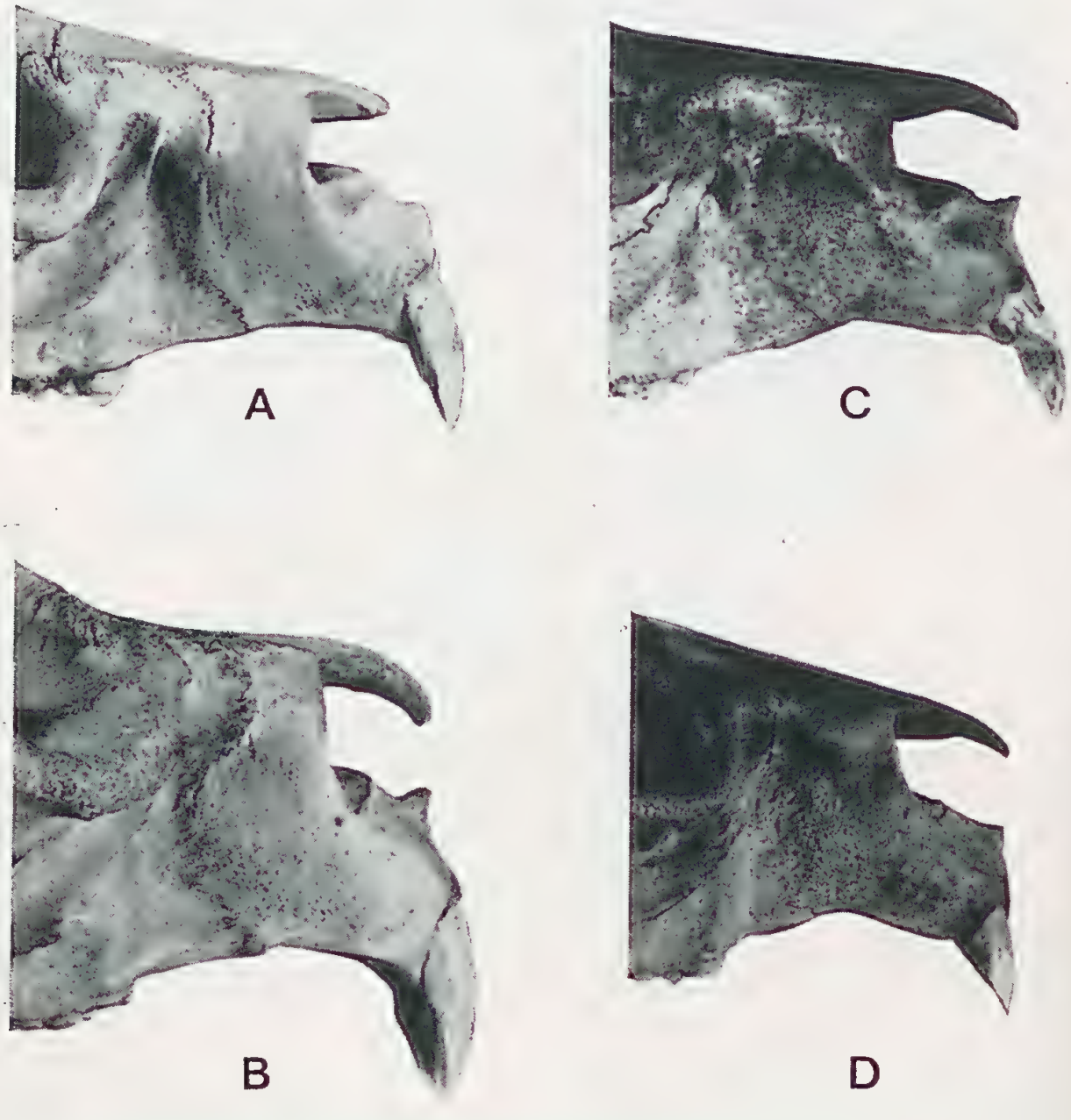


Fig. 7. Lateral view of muzzle in: A, *L. latifrons* from Nullarbor; B, *L. barnardi* (type); C, *L. gillespiei* (type); D, *L. gillespiei* from Deniliquin.

I cannot agree with Troughton (1954), that *gillespiei* should be given generic status, but it should be recognized as a distinct species. Unless more specimens of *barnardi* are discovered, it will be preferable to regard it, too, as a separate species. It certainly has greater affinity with *gillespiei* than with *latifrons* and in such a small group the use of trinomials is hard to justify.

As the differences between the Portee and Nullarbor populations of *latifrons* are of a lower order and are mixed in the sample from half-way between them, no races of *latifrons* can be distinguished at the present time.

ACKNOWLEDGMENTS

I am indebted to the Keeper of Zoology, and Dr. G. B. Corbet for access to the British Museum material, and to the Directors of the Queensland Museum and the National Museum of Victoria for the loan of specimens.

Great assistance in the field was rendered by Messrs. A. Kowanko, H. Bowshall and W. Head of the South Australian Museum. The photographs were taken by the staff photographer, Mr. R. Ruehle.

I should also like to express my thanks to the owners and managers of Portee, Nullarbor and Yardea, for their assistance and co-operation, and especially to Mr. S. B. Armstrong of Roonka, Blanchetown, for help and accommodation on many occasions.

BIBLIOGRAPHY

Angus, G. F., 1861: Notes on the broad-fronted wombat of South Australia (*Phascolomys latifron* Owen). Proc. zool. Soc. Lond., 1861, 268-271.

De Vis, C. W., 1900: On a new species of hairy-nosed wombat. Ann. Qd. Mus., 5, 14-16, pl. X.

Gould, J., 1859-1863: *The Mammals of Australia,* 1, pl. 59-60.

Gray, J. E., 1863: Notice of three wombats in the zoological gardens. Ann. Mag. nat. Hist., 11 (3rd ser.), 457-459.

Iredale, T. and Troughton, E. L., 1934: A check-list of the mammals of Australia. Mem. Aust. Mus., 6, 1-122.

Kershaw, J. A., 1909: Notes on the hairy-nosed wombat *Phascolomys latifrons* Owen. Victorian Nat., 26, 118-119.

Longman, H. A., 1939: A central Queensland wombat. Mem. Qd. Mus., 11, 283-287.

Mohr, E., 1942: Einiges über Wombatformen und Marsupialia Bentel. Zool. Gart. Lpz., new ser. 14, 55-68.

Murie, J., 1865: On the identity of the hairy-nosed wombat (*Phascolomys lasiorhinus* Gould) with the broad-nosed wombat (*P. latifrons* Owen). Proc. zool. Soc. Lond., 838-854.

Owen, R., 1845: (Exhibition of wombat skulls). Proc. zool. Soc. Lond., 1845, 82-83.

———— 1849: On the osteology of the Marsupialia II. Comparison of the skulls of the wombats of Continental Australia and of Van Diemen's Land, whereby their specific distinction is established. Trans. zool. Soc. Lond., 3, 303-306, pl. 37.

———— 1872: On the fossil mammals of Australia Part VI Genus *Phascolomys* Geoffr. Phil. Trans., 162, 173-196.

Spencer, W. B. and Kershaw, J. A., 1910: The existing species of the genus *Phascolomys.* Mem. Nat. Mus. Melb., 3, 37-65.

Tate, G. H. H., 1951: The Wombats (Marsupialia—Phascolomyidae). Am. Mus. Novit., No. 1525, 1-18.

Thomas, Oldfield, 1905: Suggestions for the nomenclature of the cranial length measurements and of the cheek-teeth of mammals. Proc. biol. Soc. Washington, 18, 191-196.

Troughton, E., 1954: *Furred Animals of Australia.* Angus and Robertson: Sydney, 5th Ed. (1st Ed. 1941).

NOTE ADDED IN PROOF

The continued existence of a colony on Epping Forest Station was confirmed when Messrs. D. P. Vernon and M. E. McAnna, of the Queensland Museum Staff, took a female of weight 80 lb. on 5th September, 1966, at Wombat Bore, 85 miles N.W. of Clermont.

CRANIAL AND MANDIBULAR CHARACTERS OF MODERN MAINLAND WOMBATS (MARSUPIALIA, VOMBATIDAE) FROM A PALAEONTOLOGICAL VIEWPOINT, AND THEIR BEARING ON THE FOSSILS CALLED PHASCOLOMYS PARVUS BY OWEN (1872)

By D. MERRILEES, Western Australian Museum, Perth

With 5 figures in the text

SUMMARY

Samples of the two kinds of wombats (*Lasiorhinus latifrons* and *Vombatus hirsutus*) at present living on the Australian mainland are compared in this paper in order to establish criteria for the identification of fossil wombats. Wide ranges of variation are demonstrated in many structures and it is shown that tooth size has not the same diagnostic value in wombats as in most mammals.

Phascolomys parvus Owen, 1872, as it is exemplified by its lectotype (herein selected as British Museum (Natural History) specimen 32893) is shown to be a juvenile wombat probably not separable from *Vombatus hirsutus* (Perry, 1810).

INTRODUCTION

It is generally considered that two kinds of wombats inhabit the Australian mainland at the present time. They are conveniently distinguished by the appearance of the rhinarium as the hairy-nosed wombats of the drier south-central and east-central regions, and the bare-nosed wombats of the wetter south-eastern region. Bare-nosed wombats also inhabit Tasmania and Flinders Island at the present time, and have inhabited other Bass Strait islands in historic time. Fossil wombats have been reported from many localities.

Several genera and many species have been proposed for the modern and fossil wombats, and these are reviewed by Tate (1951). I refer to the modern South Australian hairy-nosed wombats studied as *Lasiorhinus latifrons* (Owen, 1845) and to the modern south-eastern mainland bare-nosed wombats as *Vombatus hirsutus* (Perry, 1810). The type locality of *Opossum hirsutum* Perry, 1810 is fixed to the Australian mainland by Ride, W. D. L. (in press). This paper reports studies on some samples of *L. latifrons* and *V. hirsutus* designed to facilitate further studies on fossil wombats.

The largest of the samples studied consisted of 52 skulls and associated mandibles of bare-nosed wombats, all drawn from an area

of a few square miles near Canberra, all but one collected in 1960-1961, and all believed to be drawn from the same breeding population. This sample was loaned to me by the C.S.I.R.O. Division of Wildlife Research, and is described below as the Dingo Dell—"Fairbank" sample, individual specimens being referred to by their collection numbers, *e.g.* (C.S.I.R.O. Wildlife) CM 297. Another five bare-nosed wombat specimens from localities other than Dingo Dell—"Fairbank" were loaned to me by the C.S.I.R.O. Division of Wildlife Research, and these also are mentioned below under C.S.I.R.O. Wildlife CM numbers. The Western Australian Museum collection contained two specimens of modern bare-nosed wombats, referred to by their catalogue numbers, *e.g.* (W. Aust. Mus.) M 1621.

Modern hairy-nosed wombats examined included six skulls and mandibles of young animals loaned to me by Dr. P. Crowcroft, Director of the South Australian Museum, and these are referred to below under their field collection numbers, *e.g.*, P.C. 108. The other nine skulls and mandibles of hairy-nosed wombats examined, plus some incomplete specimens, were those of the Western Australian Museum collection, referred to as (W. Aust. Mus.) M 6552, etc.

One skull and mandible of a bare-nosed wombat from Flinders Island (CM 354) and one from Tasmania (M 6555) have been examined by me in detail, and I have been able to examine many other Tasmanian and Bass Strait islands specimens from the collections of the National Museum of Victoria and the Queen Victoria Museum and Art Gallery, Launceston. I have also been able to examine many other fossil and modern specimens in the National Museum of Victoria, fossil specimens in the Australian Museum, Sydney, and a few fossil specimens from other institutions. But I have not attempted to review all the resulting data in the present paper, and in particular, have made no attempt to assess the taxonomic relationships of the Bass Strait islands, Tasmanian and mainland populations of modern bare-nosed wombats.

My conclusions on Western Australian fossil wombats are to be reported separately, and Mr. H. E. Wilkinson (National Museum of Victoria) and I have work in hand on certain eastern Australian fossil wombats, also to be reported separately.

Copies of the raw data on which the present studies are based, together with notes on the nature and accuracy of these data, have been lodged in the libraries of the Western Australian Museum, Perth, the South Australian Museum, Adelaide, and the C.S.I.R.O. Division of Wildlife Research, Canberra.

VARIABILITY IN MODERN WOMBATS

Variability is a striking characteristic of modern wombats. The Dingo Dell—"Fairbank" sample of *V. hirsutus* is perhaps as uniform genetically as one could expect of any sample of relatively large mammals in the wild. Yet within this sample of 52 individuals, 35 show abnormalities of some kind. Relatively minor aberrations include foramina in the ectalveolar grooves, doubling of the (normally single) masseteric foramen, and rugosity of the cranium. Major aberrations include supernumary teeth and cranial sutures, palatal asymmetry, and malformation of the supraoccipital. In the more heterogeneous sample of *L. latifrons* available to me, a still greater range of aberrations is present, affecting 16 out of 25 specimens. These aberrations include inequality in the masseteric foramina of opposite sides, supernumary teeth, asymmetry in frontals and parietals, and distortion of alveoli.

Details of these aberrations are recorded with the raw data mentioned above, but some striking examples may be quoted here. Among the specimens of *L. latifrons,* W. Aust. Mus. M 3410 shows both a right upper and a left lower supernumary molar; M 4551b shows asymmetry in frontals and parietals, while its left post-orbital process is so recurved as to touch the skull wall; P.C. 32 shows the interparietal suture dividing to enclose a separate median plate, not usually found in wombats. Among the specimens of *V. hirsutus* C.S.I.R.O. Wildlife CM 350 shows a shallow pit of about 5 mm. diameter in the left frontal; CM 315 and 316 show wide infraorbital foramina (comparable with those of *L. latifrons*); CM 345 shows supernumary needle-like teeth ahead of P^4 on both sides and CM 296 shows the prezygomatic ridge ending posteriorly in a tubercle.

Longman (1939) and Tucker (1954) illustrate and describe a striking aberration in a specimen of the Queensland race of *L. latifrons,* which shows marked curvature in the long axis of the skull, with marked inequality in the lengths of the cheek tooth rows of opposite sides.

In addition to these "aberrations", wide ranges are described below in what appears to be "normal" variability in certain characters.

Intraspecific variations of such magnitude cast strong doubts on the taxonomic validity of the minutiae which have been used to distinguish such fossil wombat "species" as *Phascolomys thomsoni* Owen, 1872.

The teeth of wombats are open rooted, and continue to grow through the animal's life-time (Jones, 1924). In this respect, they resemble incisor teeth in rodents and incisor and cheek teeth in modern

lagomorphs (Dechaseaux, 1958) but differ from the teeth of most mammals. In most mammals the size as well as the shape of each kind of tooth may have diagnostic value, but wombat species cannot be differentiated on tooth size alone, since a juvenile of a large species may have smaller teeth than an older individual of a smaller species.

Figure 1 shows the very wide range in length of the cheek tooth row (as expressed in greatest length of the alveoli of P_4-M_4 inclusive) in my samples of *L. latifrons* (all included) and *V. hirsutus* (Dingo

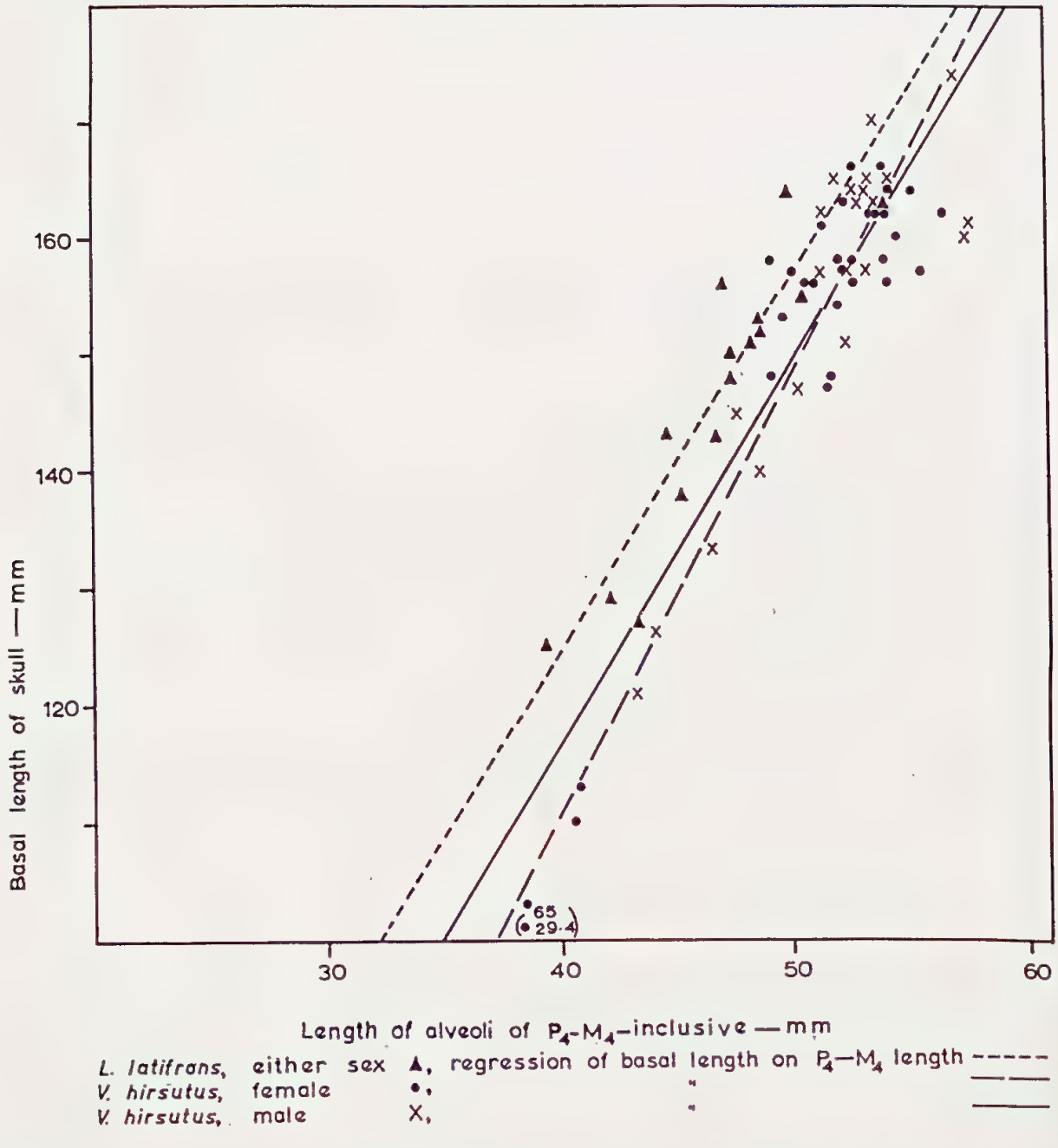


Fig. 1. Relationship between basal length of skull and length of the lower cheek tooth row in modern bare-nosed and hairy-nosed wombat samples. *L. latifrons*, all available specimens; *V. hirsutus* from Dingo Dell—"Fairbank").

Dell—"Fairbank" only). Figure 2 shows the very wide range in width of one particular tooth (M_3, fore-lobe) in these same samples. Figure 1 shows also that length of the cheek tooth row is closely dependent on the size of the individual as expressed by basal length of the skull. Figure 2 shows in turn that width of one particular tooth is closely dependent on length of the whole cheek tooth row and hence on size of the individual. Individual differences are evident at a glance in figs. 1 and 2, whereas species differences are only clear from the fitting of regression lines.

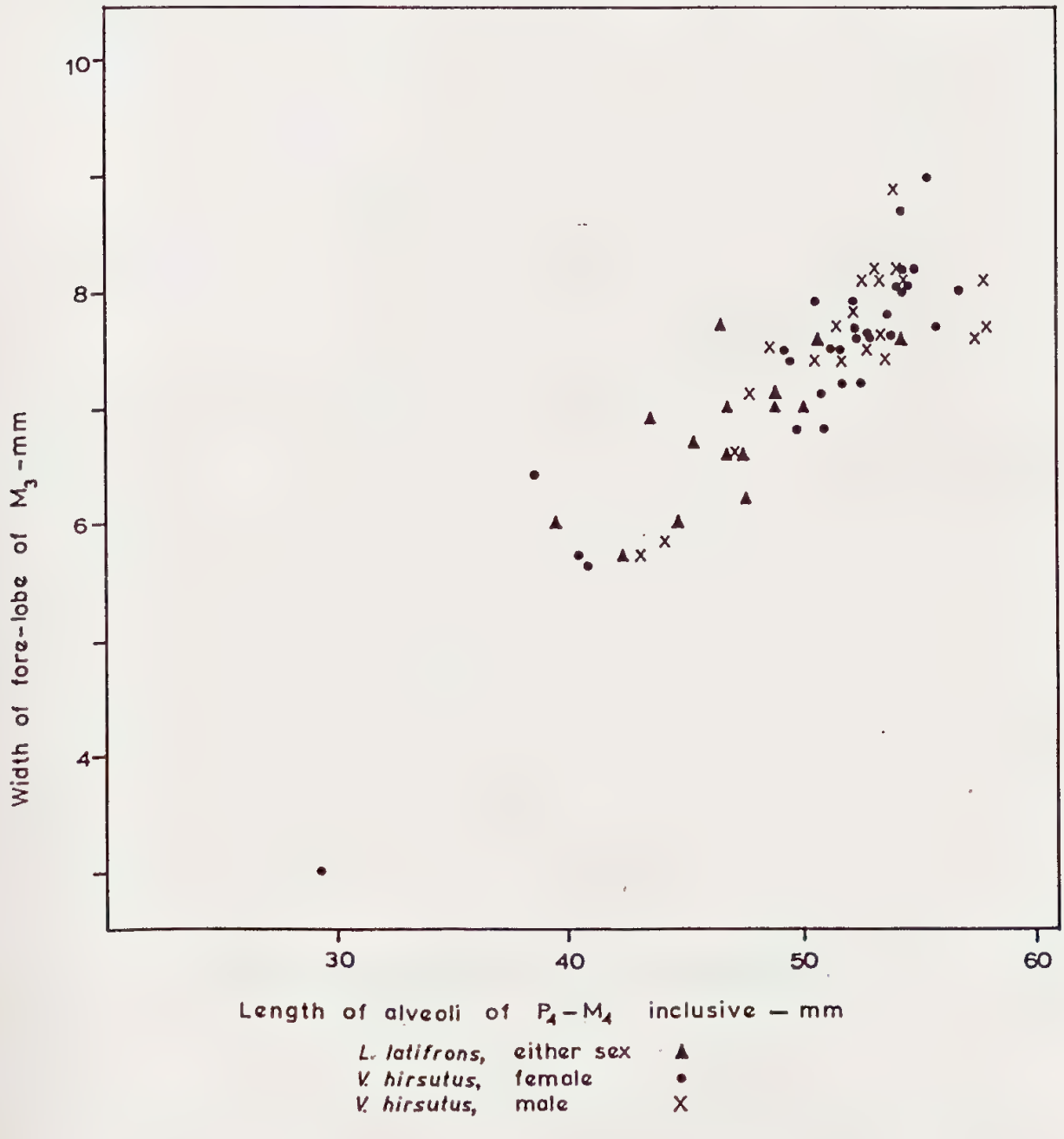


Fig. 2. Relationship between length of the lower cheek tooth row and width of a representative constituent tooth (M_3) in modern wombats. (Same samples as in figs. 1 and 4.)

Owen (1872) and many other writers have suggested size criteria for distinguishing wombat species from the teeth, but figs. 1 and 2 suggest that size criteria can be used only with caution.

COMPARISON OF MOLAR TEETH OF *L. LATIFRONS* WITH THOSE OF *V. HIRSUTUS*

All cheek teeth in both species of wombats are open rooted, and throughout its length, each tooth is uniform in cross-sectional shape and size. In both species, the curvature appears to be more pronounced (*i.e.*, the radius of curvature appears to be smaller) in upper than in lower teeth, but the difference is more noticeable in *V. hirsutus* than in *L. latifrons*. In both species, the curvature appears to be more pronounced in the forward than in the rear teeth in a given tooth row, e.g., M_1 is more curved than M_4. In both species, the nature of the curvature differs between upper and lower cheek teeth, the convexity being lingual for the upper and buccal for the lower tooth rows. Consequently, when seen in contact from behind or in front, each upper cheek tooth and its corresponding lower form a sigmoid curve, and the grinding surfaces in contact form part of a horizontal plane intersecting this sigmoid curve.

Both upper and lower molar teeth in both species are bilobate structures, with a deep embayment in the lingual aspect of each upper and the buccal aspect of each lower tooth, and with a smaller embayment on the opposite side. In the words of Bensley (1903), "each tooth shows two triangular pillars; the sectional apices are directed outwards in the lower teeth and inwards in the upper".

Presumably because of their open roots, wombat teeth very easily fall out of their sockets in dried skulls and mandibles; in fossil deposits, wombat cheek teeth are separated from their maxillae or mandibles more commonly than in most other kinds of marsupials.

Only in the very youngest individual wombats does any trace of cusps persist. For example in C.S.I.R.O. Wildlife CM 359 (the pouch young of CM 358) of basal length of skull only 65 mm., with $P^{\frac{4}{4}}$ and M_3 not fully erupted, and with M^3 and $M^{\frac{4}{4}}$ still in alveolus, wear facets are discernible on $I^{\frac{1}{1}}$, $M^{\frac{1}{1}}$ and $M^{\frac{2}{2}}$, *i.e.*, on all fully erupted teeth, though the cusp pattern predominates over the wear pattern. On the next smallest individual available to me (CM 316, of basal length 103 mm.) the whole occlusal surface of each cheek tooth is a flat wear face, with no remaining trace of cusps.

Sometimes in M^1 and M^4, less often in M_1 and M_4, inequalities in size between the lobes indicate the antero-posterior axis of a molar tooth, but often with isolated wombat teeth with nearly equal lobes,

there is no indication of their life orientation. Often with isolated fossil wombat molars, breaks occur along the constrictions separating the lobes as well as in accidental positions across the length of the teeth. Thus, a curved fragment may be readily identifiable as part of the molar tooth of a wombat, but it may be difficult to go beyond this.

Absence of cusps, gradations in the degree of curvature between upper and lower or front and rear teeth in a given individual, and lack of marked inequality between molar lobes, may render difficult or impossible a decision on the approximate place in the tooth row or the species of the animal concerned. Sometimes, knowledge of the life position of an isolated tooth could facilitate identification of its species, so that the common uncertainty about position is very unfortunate.

Various observers have suggested criteria for distinguishing between wombats affiliated with *V. hirsutus* and those affiliated with *L. latifrons* on the basis of morphological characters in the molars. For example Tate (1951) contrasts "molars not narrowed" in *Vombatus* with "molars narrow" in *Lasiorhinus* in his "Key to the Genera of Wombats", and De Vis (1891) contrasted his "*Phascolomys angustidens*" with *P. mitchelli* and *P. platyrhinus* partly in its showing "teeth narrow, in a relatively long series". My comparisons, however, do not suggest any readily recognizable differences in tooth width between the *L. latifrons* and *V. hirsutus* samples studied. The difficulties are illustrated by fig. 2, which plots lateral width at the occlusal face of the forward lobe of M_3 teeth in the two species against total length of the alveoli of the cheek teeth (P_4-M_4). I have not measured width of other molars, but visual inspection fails to reveal any conspicuous narrowness in molar teeth in *L. latifrons*.

Dealing with isolated wombat teeth from the Balladonia fossil deposits, Glauert (1912) states that the outline of the working surface, the extent of the external enamel, and the nature of the longitudinal grooving are diagnostic of wombat species, but he gives no details.

My own comparisons between modern *L. latifrons* and *V. hirsutus* in respect of distribution of enamel on molar teeth do not support Glauert's assertion. Enamel distribution appears to be very similar in the two species.

With "longitudinal grooving", one distinction does appear in lower molars of *L. latifrons,* namely, an inward curvature of the antero-buccal aspect of the fore lobe, extending from root to occlusal face. This inward curvature is apparent when viewing the occlusal surface from above, and manifests itself as a depression along the tooth which might be described as a "groove" when isolated teeth

are viewed. All 16 right M_3 teeth of *L. latifrons* examined in detail by me show this depression, whereas none of the 37 right M_3 teeth of *V. hirsutus* examined does so, and visual inspection of other lower molar teeth suggests that the difference is almost constant. However, M_1 in W. Aust. Mus. M 6554 (*L. latifrons*) shows a depression on the postero-buccal, not on the antero-buccal aspect, and M_4 in C.S.I.R.O. Wildlife CM 603 (*V. hirsutus*) shows a somewhat similar incurving of the postero-buccal aspect. Neither species shows any similar feature in upper molars.

Thus in an isolated wombat molar, an inward curvature or groove along one but not the other transverse face of the tooth would strongly suggest that it was a lower molar of *L. latifrons*.

Striations on a scale not much above the limit of naked eye observation occur on molar teeth in both modern species examined, but I could find no constant differences between the species in the scale or distribution of these fine striae.

Many molars in *V. hirsutus*, especially lower molars, show relatively deep furrows along their concave aspects (buccal in uppers, lingual in lowers). These furrows, of a greater order of magnitude than the striae just mentioned, are apparent only in isolated teeth, and do not often or much affect the occlusal outline. The hinder lobes of right $M_{2, 3, 4}$ in C.S.I.R.O. Wildlife CM 314, or both lobes of right M^4 in CM 328 provide examples. However, occasional furrows of comparable size occur in *L. latifrons* along the concave faces of molar teeth, *e.g.*, left M_1 in W. Aust. Mus. M 6554. These furrows do not appear to me to be of much diagnostic value.

As to the "outline of the working surface" said by Glauert (1912) to be specifically diagnostic, this is a reflection of the general form of the tooth, and my comparisons of molar teeth do suggest specific distinctions, particularly with lowers. The distinction may be summed up as greater angularity in *V. hirsutus*. In 37 right M_3 teeth of *V. hirsutus* examined in detail, 29 show a distinctly angular corner between the lingual face and the posterior face, and cross-sectional outlines in all 37 show an abrupt change in direction from approximately antero-posterior to approximately lateral. By contrast, in all 16 right M_3 teeth of *L. latifrons* similarly examined, the transition from lingual to posterior face is a smoothly rounded curve. Not only do M_3 teeth show this specific contrast, but so do other lower molars. Upper molars in *V. hirsutus* also show sharper transition from lateral to buccal (concave) faces than do upper molars of *L. latifrons*, but the contrast is less marked than in lower molars.

Likewise the apices of the lobations in *V. hirsutus* molars appear very often to be much sharper than in *L. latifrons*—for example, the right M_2 of C.S.I.R.O. Wildlife CM 603 (*V. hirsutus*) contrasts with W. Aust. Mus. M 6552 (*L. latifrons*). This apical angularity is not invariably distinctive—for example, right M_1 is comparable in CM 314 (*V. hirsutus*) and M 6553 (*L. latifrons*)—but it appears to me to be of sufficient constancy to have some diagnostic value.

Angularity in *V. hirsutus*, both in apices of the molar lobes and in sharpness of transition from lingual to lateral faces in lower molars or buccal to lateral faces in upper molars, is illustrated in fig. 3 below,

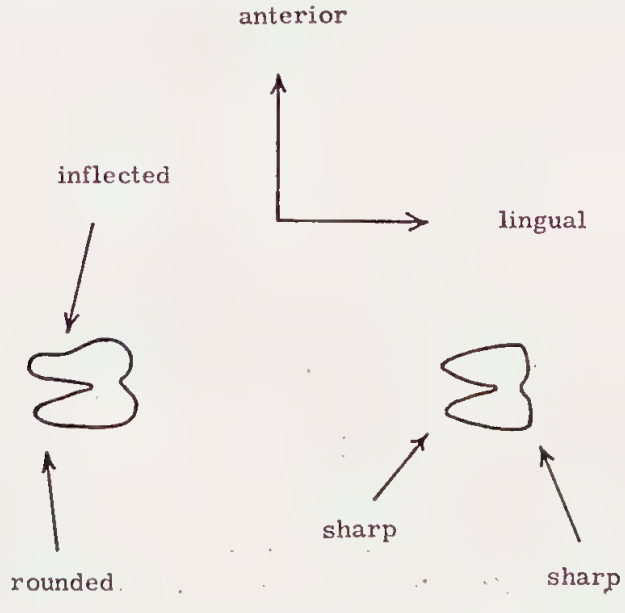


Fig. 3. Occlusal outlines of lower molars in modern *Lasiorhinus latifrons* (left) and *Vombatus hirsutus* (right) to show diagnostic characters. Not to scale.

and is discernible three-dimensionally in isolated teeth removed from their sockets as well as in the two-dimensional view presented by the occlusal faces. Contrast between the species shows quite clearly in the illustrations provided by Owen (1872); contrast, for example, his fig. 1 (“*Phascolomys latifrons*”) of pl. XX with his fig. 3 (“*Phascolomys platyrhinus*”).

COMPARISON OF PREMOLAR TEETH OF *L. LATIFRONS* WITH THOSE OF *V. HIRSUTUS*

Lower premolars in both species may show polygonal cross-sections, but whereas in *L. latifrons* the polygons are approximately equidimensional, in *V. hirsutus* they are usually elongate, with longer horizontal axes making angles with the antero-posterior axes of the mandibles varying from about 10° (*i.e.*, nearly antero-posterior, in C.S.I.R.O. Wildlife CM 350) to about 50° (in CM 313 or CM 349).

Some *V. hirsutus* P_4 teeth are very narrow relative to their greatest diameter, *e.g.,* CM 358 is 7.4 mm. in greatest diameter, 4.6 mm. in least diameter, at the occlusal face. The most elongate P_4 seen by me in *L. latifrons* is W. Aust. Mus. 4551i, measuring 6.1 mm. in greatest occlusal diameter, 4.2 mm. in least. A more typical *L. latifrons* P_4 is M 385, with an irregularly pentagonal occlusal surface 6.5 mm. in greatest diameter, 5.4 mm. in least.

On the other hand, P_4 teeth in *V. hirsutus* sometimes resemble those of *L. latifrons* in appearing to be nearly equidimensional, *e.g.,* CM 317, 337, 347. CM 347 shows an irregularly pentagonal occlusal surface, 6.1 mm. in greatest diameter, 5.2 mm. in least. However, of 59 right P_4 teeth of *V. hirsutus* examined in detail, only four in my judgment might be confused with *L. latifrons* in being equidimensional and distinctly polygonal. Many P_4 teeth in *V. hirsutus* (21 of 59 in my sample) could be described as rounded (sub-elliptical rather than polygonal) in cross-section, whereas only one of 20 *L. latifrons* specimens (P.C. 29) could be so described.

Thus an isolated P_4 tooth of markedly polygonal and nearly equidimensional cross-section strongly suggests *L. latifrons* whereas an elongate P_4, particularly of almost elliptical cross-section, strongly suggests *V. hirsutus.*

In upper premolars, perhaps the most conspicuous difference between *L. latifrons* and *V. hirsutus* is the presence in the latter of a well-marked groove in the antero-lingual (*i.e.,* convex) aspects. Of 59 right P^4 teeth of *V. hirsutus* examined in detail, not one lacked such a groove, and in nearly all, it was very conspicuous. Furthermore, the existence of this groove is usually revealed by a corresponding curve in the alveolus. However, of 15 *L. latifrons* right P^4 teeth examined, seven also showed something of the kind, although in all seven, "shallow depression" (of gentle curvature) rather than "groove" (with steep walls and sharply-curved floor) might better describe the character. In both species P^4 teeth otherwise show a similar cross-section, broadly triangular, with the apex of the triangle directed postero-buccally and with the base (containing the groove previously described) facing antero-lingually.

With isolated wombat premolar teeth, confusion in identification might arise between a P_4 in *V. hirsutus* which happened to show reduction at one end of a polygonal cross-section (*e.g.,* C.S.I.R.O. Wildlife CM 342) and a P^4 in *L. latifrons* with a similar section (*e.g.,* P.C. 29). The sense of the curvature would not be distinctive in this case, the left P_4 of CM 342 curving in the same sense as left P^4 in P.C. 29 viewed in the prone position. If the teeth were isolated,

not only would this confusion (of left P_4 in CM 342 with left P^4 in P.C. 29) remain, but also right P_4 in CM 342 could be turned to curve in the same sense and to show a somewhat similarly oriented and similarly shaped cross-section as left P^4 in P.C. 29. In this latter case (right P_4 in CM 342 and left P^4 in P.C. 29), both faces then interpretable as the antero-lingually facing bases of the "triangles" of P^4 teeth show a slight indentation. Not only would there be uncertainty about whether one was dealing with an upper or with a lower premolar, but also there would still be uncertainty about the species even if the tooth were known in some way to be an upper premolar, not a lower.

With isolated premolars there would appear also to be some possibility of confusing P_4 of *L. latifrons* (*e.g.*, W. Aust. Mus. M 4551e) with P^4 of *V. hirsutus* (*e.g.*, C.S.I.R.O. Wildlife CM 335), both showing a relatively slight depression or very shallow groove along the convex aspect.

COMPARISON OF INCISOR TEETH OF *L. LATIFRONS* WITH THOSE OF *V. HIRSUTUS*

Lower incisors of *L. latifrons* are easily distinguished from those of *V. hirsutus* by their cross-sectional form and proportions. In both species, enamel appears to be restricted to the lower face of an I_1 tooth, and the "width" of the tooth across this lower enamelled face was recorded for 16 right lower incisors of *L. latifrons* and 52 of *V. hirsutus*. Another quantity, called "height" not quite perpendicular to "width" was also recorded. "Height", "width" and another quantity (not measured) representing the length of the (curving) tooth could be regarded as 3 axes in some sense expressing the three-dimensional size and shape of the whole tooth, though not coinciding respectively with the strict vertical, lateral and antero-posterior axes of the mandible. In all 16 examples of *L. latifrons* "height" exceeded "width", whereas in all 52 examples of *V. hirsutus*, "width" exceeded "height".

Thus, as viewed from the front, protruding from their alveoli, lower incisors of *L. latifrons* are seen as high, narrow teeth, whereas those of *V. hirsutus* are low and wide. Furthermore, they are differently emplaced in the jaw, in that the enamelled surface in *L. latifrons* lower incisors faces more directly downward, whereas in *V. hirsutus* it faces as much laterally as downwards. Owen (1872) describes and figures this contrast—see his pl. xxiii, fig. 8 ("*Phascolomys platyrhinus*") and 9 ("*Phascolomys latifrons*") and pl. xx, fig. 2a ("*Phascolomys Krefftii*") and 4a ("*Phascolomys platyrhinus*").

Upper incisors are also distinctive in the two species. Viewed in position in the skull, I^1 in *L. latifrons* is more nearly scalpriform and more nearly laterally placed than is I^1 in *V. hirsutus*; the latter has a more nearly equidimensional cross-section, and is placed very obliquely. These differences are also clear in isolated teeth. In *L. latifrons* it is in general the broader faces of an I^1 tooth which are curved, in *V. hirsutus* the narrower faces. However, individual I^1 teeth are not so geometrically regular that gradations are impossible, and a decision on specific identity might be difficult if one had only the isolated left I^1 teeth of W. Aust. Mus. M 6552 (*L. latifrons*) and C.S.I.R.O. Wildlife CM 335 (*V. hirsutus*). I^1 in M 6552 is rather more equidimensional than is typical of *L. latifrons*, and I^1 in CM 335 is rather less equidimensional than is typical of *V. hirsutus*.

One very distinctive difference between *L. latifrons* and *V. hirsutus* lies in the relative proportions of lower incisor and premolar teeth. These relative proportions may be expressed as the ratio between minimum diameter of P_4 at the occlusal surface (irrespective of direction), and "width" of I_1 measured as described above across the enamelled face. In 16 lower incisors of *L. latifrons*, the ratio minimum diameter of P_4/"width" I_1 varied between 78% and 93%. In 51 lower incisors of *V. hirsutus* (excluding pouch young specimen CM 359) this ratio varied between 44% and 64%. In rough terms, lower incisors and lower premolars are of comparable size in *L. latifrons*, whereas in *V. hirsutus*, the incisors are much larger than the premolars.

Wear on upper incisor teeth in *L. latifrons* commonly produces an almost vertical facet on the hinder surface, whereas upper incisors in *V. hirsutus* commonly show an almost horizontal wear facet. However, wear facets in other planes commonly accompany these vertical or horizontal facets, to the extent that the difference between the species may be obscured.

COMPARISON OF *L. LATIFRONS WITH V. HIRSUTUS* IN SKULL AND JAW STRUCTURES OTHER THAN TEETH

Since tooth differences between wombat species are to some extent overshadowed by differences between individuals, bone structures assume relatively greater diagnostic importance in fossil wombats than in many other mammals. Fortunately, many such bone structures clearly differentiate *L. latifrons* from *V. hirsutus*, and some of the differences likely to be useful to palaeontologists are summarized in table 1.

Some of the characters listed in table 1 are reported here for the first time, others have been noted by earlier observers (especially Owen, 1872; Lydekker, 1887; De Vis, 1891; Jones, 1924 and Tate, 1951) but all have been tested in direct comparisons among my samples. Amplification of the short statements in table 1 follows.

Minimum width between the alveoli of M^1 teeth of opposite sides (measured in a horizontal straight line) appears to me to be a particularly useful diagnostic character, because it is easily expressed numerically, and because the numerical values in the two species show

TABLE 1

Summary of non-dental structures differentiating modern *Lasiorhinus latifrons* from *Vombatus hirsutus*. For further details, see text.

Structure	Nature in *L. latifrons*	Nature in *V. hirsutus*
1. Palate between M^1 teeth of opposite sides	Wide	Narrow
2. Nasals, ratio (combined) breadth : length (of either)	About 1	Much less than 1
3. Angle between fronto-nasal and internasal sutures	Close to 90°	Much less than 90°
4. Lacrymal tubercle	Small	Large, with distinct "neck"
5. Postorbital process	Large	Small
6. Premaxillary portion of palate	Deeply hollowed	Shallow
7. Anterior palatal vacuity	Short	Long
8. Palate between molars	Smooth	Patterned with minor rugosities
9. Bulla, extent of opening (as viewed in prone position)	Small	Large
10. Narial opening, vertical extent (as viewed from front)	Low	High
11. Infraorbital foramen	Wide	Narrow
12. Jugo-maxillary suture above M^1 and M^2 (as viewed from side)	Markedly convex downwards	Weakly or not convex downwards
13. Convexity outwards of maxilla above M^4	Flat or slightly concave	Convex
14. Supratympanic cell	Very deep and very long	Shallow
15. Paroccipital process	Small	Large
16. Upward convexity of symphysial region behind incisors	Flat	Convex
17. Maximum height of ramus	More anterior (below M_2)	More posterior (below M_3)
18. Anterior border of coronoid process at molar occlusal level	More anterior (level with M_3–M_4 interspace)	More posterior (level with M_4)
19. Masseteric fossa	Shallow	Deep
20. Masseteric foramen	Absent or small	Large

almost no overlap. See fig. 4, which compares my (rather heterogeneous) sample of *L. latifrons* with the homogeneous Dingo Dell—"Fairbank" sample of *V. hirsutus*; clarity of separation is not blurred by the inclusion of seven specimens of *V. hirsutus* from other localities, nor even by the inclusion of my single specimen each of the Tasmanian and of the Bass Strait islands bare-nosed wombats. In addition,

measurements from fragmentary specimens, split along the intermaxillary suture, may be used with confidence, since in only one of my modern specimens of both species (CM 307, *V. hirsutus*) is there perceptible asymmetry in this region.

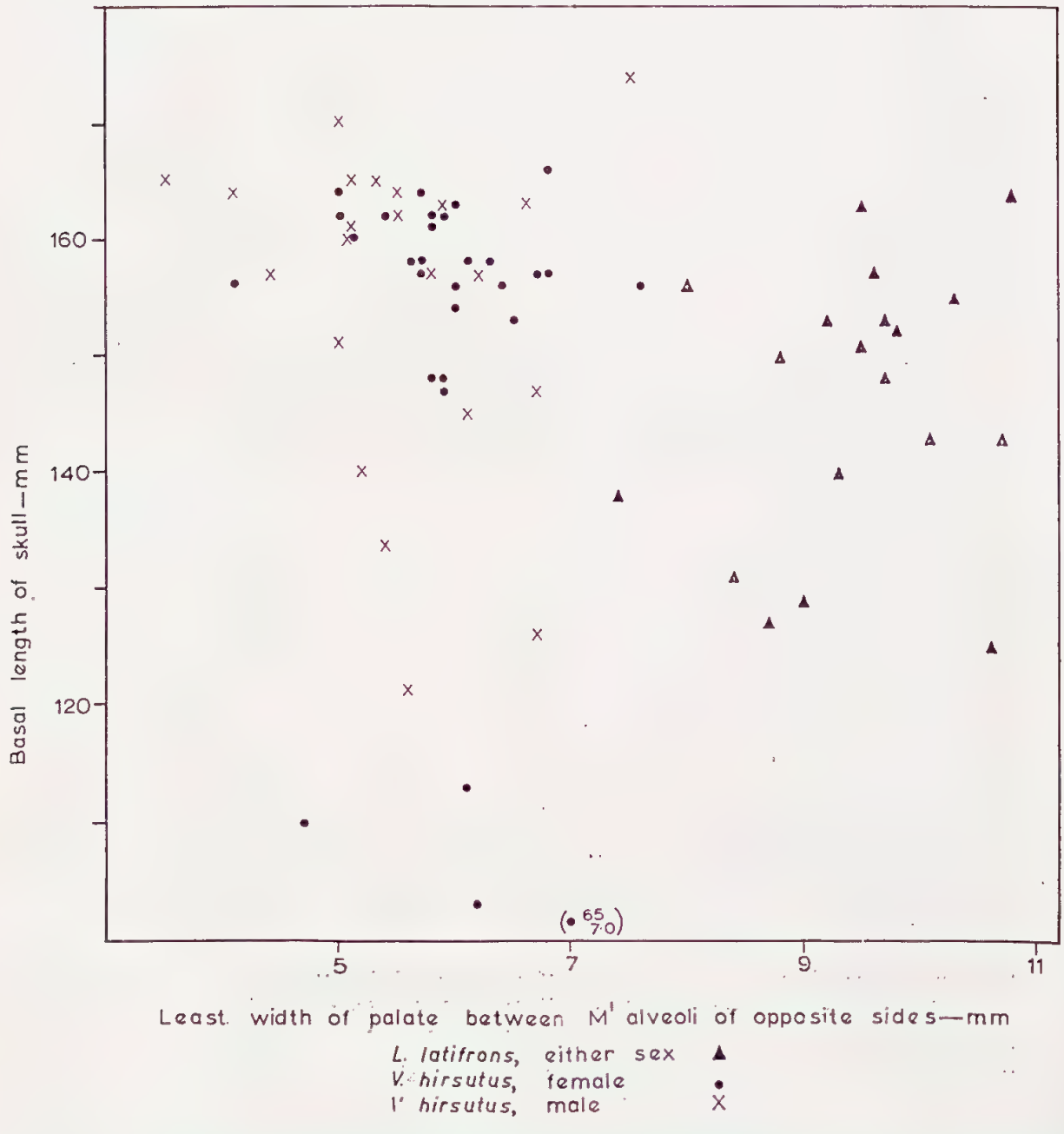


Fig. 4. Relationship between basal length of skull and palate width at M1 in modern wombats. (Same samples as in figs. 1 and 2.)

Not only does fig. 4 show a marked difference between *L. latifrons* and *V. hirsutus,* with very little overlap, by absolute width of palate at M¹, but it suggests also that this quantity is almost completely independent of skull size and therefore probably of age of the

individual animal. Thus it may be claimed that the quantity "least width of palate at M^1" in wombats can serve much the same diagnostic function as tooth size serves in the majority of mammals, in which the teeth, once fully formed and enamelled, do not change further during the life of the individual. Figures 1 and 2 show that size of the teeth in modern wombats is closely linked with skull size, and therefore will not serve to differentiate species; this is a point of some importance, with a corollary affecting Owen's species "*Phascolomys parvus*", discussed below.

Other non-dental distinctions between *V. latifrons* and *V. hirsutus* set out in table 1 are in many cases not absolute. Ranges of variation shown by the composite *L. latifrons* sample may be contrasted with the homogeneous sample of *V. hirsutus* from Dingo Dell—"Fairbank", for example, in the ratio of combined breadth/length in nasals (*L. latifrons* 96%-113% and *V. hirsutus* 66%-88%). But in angle between fronto-nasal and internasal sutures the ranges are *L. latifrons* 80-100°, *V. hirsutus* 50-80°; of 52 skulls of *V. hirsutus* only one reaches 80°, whereas of 19 (measurable) skulls of *L. latifrons*, only three do not exceed 80°. Length of the anterior palatal vacuity ranges from 3 to 7 mm. in *L. latifrons* and from 3 to 13 mm. in *V. hirsutus*, though in the sample of 52 specimens of *V. hirsutus*, 47 exceed 7 mm. in length of anterior palatal vacuity, which accordingly is entered as "long" for this species in table 1.

For less easily measurable characters, it is correspondingly less easy to express the extent of any overlap. For example (buccal) convexity in the maxilla just above M^4 is most easily registered by touch; 31 of 52 specimens of *V. hirsutus* from Dingo Dell—"Fairbank" are so registered as markedly convex in this region, and only one is not perceptibly convex, this one being flat. In 19 specimens of *L. latifrons*, eight are slightly convex, eight flat and three slightly concave above M^4. Maximum vertical height of the mandibular ramus was judged to be greatest beneath the posterior lobe of M_1 in one specimen of *L. latifrons* and beneath the M_2-M_3 interspace in three specimens, but in ten (of a total of 19) it is beneath some part of M_2. Among 52 specimens of *V. hirsutus*, the ramus is highest as far forward as M_2 in two specimens (or even the posterior lobe of M_1 in pouch young CM 359) and as far back as the M_3-M_4 interspace in three specimens, but in 35 specimens the ramus is highest below some part of M_3. In *L. latifrons*, the anterior borders of the coronoid processes of opposite sides, lined up in side view at the molar occlusal level, fall opposite the hinder lobe of M_3 in seven specimens and the middle of M_4 in one specimen, but in the majority (11 of a total of 19), opposite

the interspace between M_3 and M_4 or opposite the forward lobe of M_4. In *V. hirsutus,* on the other hand, the anterior border of the coronoid ascends as far forward as the hinder lobe of M_3 only in one specimen (pouch young CM 359), and is as far or further back than the middle of M_4 in 50 specimens in a total of 52.

The masseteric foramen is recorded in table 1 as "large" in *V. hirsutus,* though its (horizontal) diameter ranged from 1 mm. (in pouch young CM 359) to 5½ mm. in each of two specimens (CM 295 and CM 343); in 37 of 52 specimens, the diameter of the masseteric foramen was 4 mm. or more. No specimen lacked a masseteric foramen, and three specimens (CM 340, 342, 348) each bore two foramina. In *L. latifrons,* three specimens in 19 lacked a masseteric foramen altogether, one specimen (M 385) lacked one on the right but showed one on the left, one specimen (P.C. 152) showed two on the right side and one on the left. But in no specimen of *L. latifrons* did the diameter of the masseteric foramen exceed 3½ mm.; therefore it has been entered as "absent or small" in *L. latifrons* in table 1.

In *V. hirsutus* the masseteric fossa is generally a deep pouch separated from the alveolus of M_4 by only a thin wall of bone. The masseteric fossa is generally much shallower in *L. latifrons.* Nevertheless there is much gradation between the species. If one had only a small portion of the mandible of the immature *L. latifrons* specimen P.C. 108 (with a relatively deeply pouched masseteric fossa and a relatively large masseteric foramen) one might well remain in doubt whether it represented a very immature *V. hirsutus* or a somewhat older *L. latifrons.*

Similarly, although the lacrymal tubercle is generally larger in *V. hirsutus* than in *L. latifrons,* there is little difference in size of the lacrymal tubercle between P.C. 152 (*L. latifrons*) and C.S.I.R.O. Wildlife CM 337 (*V. hirsutus*).

Of the other differential characters set out in table 1, there is considerable gradation between the species in nos. 6 (depth of premaxillary portions of palate), 10 (height of narial opening), 12 (downward convexity of jugo-maxillary suture above M^1 and M^2) and 15 (size of the paroccipital process). On the other hand, nos. 5 (size of the postorbital process), 9 (extent of the bullar opening) and 14 (size of the supratympanic cell) appear to be highly diagnostic.

Phascolomys parvus Owen, 1872

Phascolomys parvus is a species of fossil wombats distinguished by Owen (1872) from other wombat species known to him by the small size of specimens he assumed to be adult because their teeth were very

worn. Owen's concept of this small wombat species was based on three specimens now in the fossil mammal collection of the British Museum (Natural History), and the name *P. parvus* is here fixed upon one of these specimens by lectotype selection.

Selection of lectotype: I hereby designate as the lectotype of *Phascolomys parvus* (Owen, 1872) specimen no. 32893 in the collection of the British Museum (Natural History). This is the specimen stated by Lydekker (1887) to be "the type specimen". The type locality for *P. parvus* is King's Creek, Darling Downs, Queensland.

Owen (1872) describes and figures two specimens (specimen 32893—Owen's pl. 20, fig. 6, 7, 8 and pl. 23, fig. 6, 7 and specimen 32899—pl. 19, fig. 6, 7); he mentions a third specimen (32911x), and he figures a fourth specimen (43303x—Owen's pl. 38, fig. 5, 6) with description in Part 7 of his "Phil. Trans." series, that dealing with the larger fossil wombats. Specimens 32893, 32899 and 32911 are all stated by Owen (1872) to come from King's Creek, Darling Downs, Queensland, while specimen 43303 is stated by Lydekker (1887) to come from "a cavern in the Wellington Valley, New South Wales". (Lydekker, 1887 states that 43303 is a fragment of the right ramus of a mandible, whereas Owen's (1872) figure shows a left ramus.)

Owen (1872) states that his specimens must be adult because of "the well worn crowns of the molars". However, marked signs of wear on molar teeth, even the hindmost molars, do not distinguish very young from old wombats. For example, C.S.I.R.O. Wildlife skull CM 316, a young female with its basisphenoid-basioccipital suture still wide open, its interfrontal suture still plainly visible and a "basal length" of only 103 mm., shows wear on M_4^4 teeth comparable with the wear on M_4^4 teeth in CM 332, an older female of basal length 166 mm. with completely fused basioccipital-basisphenoid and interfrontal sutures. Wear on the teeth of pouch young specimen CM 359 (basal length 65 mm.) has been mentioned above under the heading "Comparison of molar teeth of *L. latifrons* with those of *V. hirsutus*". Evidently, at some growth stage between basal skull lengths of about 65 mm. and about 100 mm., all molar teeth in modern *V. hirsutus* assume flat wear faces.

Although Owen (1872, p. 185) realized that wombat teeth increase in size as the individual grows, apparently he did not appreciate the magnitude of this growth, for he used tooth size among other variates to draw distinctions between *P. platyrhinus, P. mitchelli* and *P. vombatus,* as well as elsewhere citing small tooth size as one of the characters diagnostic of *P. parvus.* Figures 1 and 2 above show that

tooth size in both modern *L. latifrons* and modern *V. hirsutus* varies directly with age (as measured by basal length of skull) in the individual.

I suggest that Owen's *P. parvus* was based on juvenile specimens of some other species. Figure 5 below shows smaller and larger specimens of *V. hirsutus*, both females, both taken in the same year from the same breeding population, and yet differing from one another in the same manner as Owen (1872) differentiates his *P. parvus* from *P. vombatus* (his name for the living bare-nosed wombats of Tasmania) and *P. platyrhinus* (his name for the living bare-nosed wombats of the Australian mainland). Table 2 below sets Owen's description of *P. parvus* alongside descriptions of two young specimens of *V. hirsutus* from the Dingo Dell—"Fairbank" series.

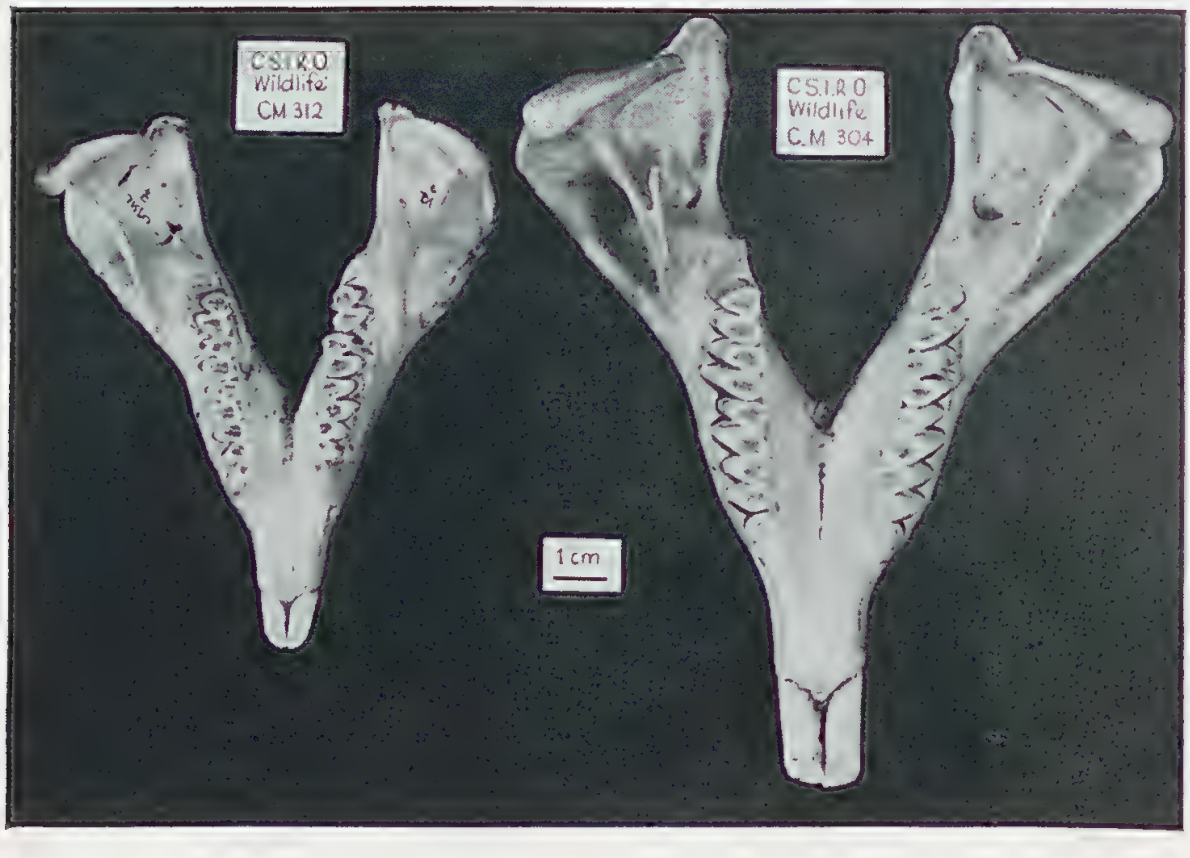


Fig. 5. Comparison of tooth sizes in younger (left) and older (right) specimens, both females of *Vombatus hirsutus* taken in 1960 from the Dingo Dell—"Fairbank" population near Canberra. Specimen CM 312 agrees with *Phascolomys parvus* Owen, 1872.

This detailed comparison of *P. parvus* with juvenile *V. hirsutus* reveals some discrepancies. But Owen's statements in his text (Owen, 1872) sometimes do not quite agree with his illustrations, which are stated all to be "of natural size"; examples are marked * in table 2.

Further, Owen's (Queensland) specimens and Dingo Dell—"Fairbank" specimens CM 312 and CM 316 certainly represent different populations and may have been of slightly different growth stages. Therefore, it is still reasonable, in spite of the slight discrepancies, to suggest that *Phascolomys parvus* Owen, 1872 is conspecific with the Dingo Dell—"Fairbank" sample of *Vombatus hirsutus* (Perry, 1810). If so, Owen's prophecy (1872, p. 255) that ". . . the diminutive *Phasc. parvus* may yet be found living . . ." had probably been fulfilled even before he made it.

TABLE 2

Comparison of *Phascolomys parvus* Owen with juveniles of *Vombatus hirsutus* (Perry)—left mandibular rami.

Character Examined	*P. parvus* Data from Owen (1872) and Lydekker (1887) anatomical notation revised D.M.	*V. hirsutus—juveniles* Original data from C.S.I.R.O. series, Dingo Dell—"Fairbank", N.S.W.	
		CM 312	CM 316
Length P_4–M_4, at occlusal faces	34mm.–36mm.	35.6mm.	35.5mm.
Backward extent of symphysis	*M_1–M_2	M_3–M_4	Hind lobe M_2
Hind contour of symphysis ...	Lobate	Lobate	Lobate
Occlusal face P_4	Sub-elliptic, long axis nearly parallel* with jaw-line	Sub-elliptic, long axis transverse to jaw-line	Elliptic, long axis transverse to jaw-line
Major and minor axes of P_4 ..	4.3 x 2.2mm.	4.4 x 2.9mm.....	4.6 x 2.8mm.
Maximum length or width in any molar	*Less than 7.5mm.	M_2 = 7.8mm.	M_3 = 8.1mm.
Fore lobe M_1	Smaller than other lobes of molars	Slightly smaller than other lobes	Slightly smaller than other lobes
Hind lobe M_4			
Hinder part of diastemal tract.	Bounded by ridge, and transversely concave	Bounded by ridge, and slightly concave	Bounded by ridge, and slightly convex
Mental foramen	About half-way between alveoli of P_4 and I_1	Nearer to P_4	Nearer to P_4
Outer enamelled surface I_1 ...	Transversely and vertically convex	Transversely and vertically convex	Transversely and vertically convex
Floor of pterygoid fossa	Partially divided ..	Partially divided ..	Partially divided
Length of base of coronoid process	c. 13mm.....	c. 16mm.....	c. 15mm. .
Vertical diameter I_1.....	*Equal to occlusal length M_1	Less than occlusal length M_1	Less than occlusal length M_1

In all specimens, lower contour of ramus, relative depth of masseteric fossa, relative width of ectalveolar groove, and shape and relative size of lower incisor agree with older specimens from C.S.I.R.O. series.

* Owen's statement, apparently not in agreement with his illustrations.

ACKNOWLEDGMENTS

I am grateful to Mr. J. H. Calaby (C.S.I.R.O. Division of Wildlife Research) for arranging the loan of the large sample of *Vombatus hirsutus* skulls and jaws on which this study is largely based, and for his comments at several stages of the work. Dr. P. Crowcroft and Mr. P. F. Aitken (both of the South Australian Museum) very kindly supplied juvenile specimens of *Lasiorhinus latifrons* to supplement the sample otherwise available to me.

Dr. W. D. L. Ride and Dr. G. M. Storr (Western Australian Museum) have given me valuable advice and criticism at several stages. I am grateful to the Directors of the National Museum of Victoria and the Australian Museum, Sydney, for permission to examine specimens in their care, and to Messrs. T. A. Darragh and H. O. Fletcher for facilitating these observations. I have profited from discussions with Mr. H. E. Wilkinson (National Museum of Victoria) on the interpretation of numerous fossil wombat specimens under investigation by him. Mr. D. G. Gordon took the photograph here reproduced as fig. 5.

REFERENCES

Bensley, B. A., 1903: On the evolution of the Australian Marsupialia. Trans. Linn. Soc. Lond. Zool. (2)9: 83-217.

De Vis, C. W., 1891: Remarks on post-Tertiary Phascolomyidae. Proc. Linn. Soc. N.S.W. (2)6: 235-246.

Dechaseaux, C., 1958: *Traité de Paléontologie,* Tome 6. L'origine des Mammifères . . ." Vol. 2 (ed. J. Piveteau—Masson: Paris).

Glauert, L., 1912: Fossil remains from Balladonia in the Eucla Division. Rec. W. Aust. Mus., 1: 47-65.

Iredale, T. and Troughton, E. le G., 1934: A check-list of the mammals recorded from Australia. Mem. Aust. Mus. 6.

Jones, F. Wood, 1924: *The Mammals of South Australia.* Pt. 2 (Govt. Print.: Adelaide).

Longman, H. A., 1939: A central Queensland wombat. Mem. Qd. Mus., 11: 283-287.

Lydekker, R., 1887: "Catalogue of the fossil Mammalia in the British Museum (Natural History)". Pt. 5 [Phascolomyidae 146-160]. (British Museum (Natural History): London.)

Owen, R., 1872: On the fossil mammals of Australia. Part 6. Genus *Phascolomys* Geoffr. Phil. Trans. 1872: 173-196.

Tate, G. H. H., 1951: The wombats (Marsupialia, Phascolomyidae). Amer. Mus. Novit. no. 1525: 1-18.

Tucker, R., 1954: Pronounced parameral differentiation in the wombat (*Lasiorhinus*). Proc. roy. Soc. Qd., 65: 71-74.

ON SCEPARNODON RAMSAYI OWEN, 1884: THE SELECTION OF A LECTOTYPE, THE CLARIFICATION OF ITS TYPE LOCALITY, AND ON ITS IDENTITY WITH PHASCOLONUS GIGAS (OWEN, 1859)

By W. D. L. RIDE, The Western Australian Museum, Perth, W.A.

In 1873 Gerhard Krefft wrote, "I found one very thin tooth some years ago of a very peculiar form. It has the shape of a piece of hoop iron, is 5½ inches long, 1½ inches wide and ⅛th of an inch thick, and much worn below, showing the marks of the great lower tusks, and has belonged to a peculiar kind of Diprotodon".

Some years later, Krefft's successor at the Australian Museum, E. P. Ramsay, saw a similar tooth among a collection of fossils which he was asked to determine at the Melbourne Exhibition of 1880 (October 1, 1880-April 13, 1881). Ramsay knew nothing of the locality from which this specimen came beyond the fact that it was the property of the South Australian Institute and came from "the central part of South Australia, I believe near Lake Eyrie" (Ramsay, 1882). Ramsay had this tooth cast and sent it, together with a cast of another specimen which he found in the collection of the Australian Museum (no. F 9923), to Sir Richard Owen.

At the meeting of the Linnean Society of New South Wales on October 27, 1880, Ramsay exhibited his discovery, proposing the new generic name *Sceparnodon* for it "from the adze-like character of the upper incisor". Ramsay, too, thought that it represented a new marsupial allied to *Diprotodon* (Ramsay, 1881).

Like the South Australian specimen, the tooth in the Australian Museum was also from a locality unknown to Ramsay but its measurements agree reasonably well with those originally mentioned by Krefft in 1873 and it is presumably the same specimen. At present nothing is known of its origin beyond Krefft's original statement. Additional copies of the cast of the South Australian specimen are in the Australian Museum today (A 9851, L 1308); these were cast by H. Barnes.

Soon after Owen received these casts he received a specimen of *Sceparnodon* sent by Mr. C. H. Hartmann* of Toowoomba, Queensland, who had collected it at King Creek on the Darling Downs (Brit. Mus. (Nat. Hist.) no. M 1917). The two casts and the Queensland specimen

* The donor was cited as Harman by Owen, corrected to Hartmann by Lydekker (1887) p. 158. Mr. A. Bartholomai informs me that a Mr. H. Hartmann of Toowoomba, Qld., collected fossil mammals now in the Queensland Museum.

formed the basis of his description of the new species *Sceparnodon ramsayi* Owen, 1884 but, to the present, the whereabouts of the South Australian syntype has been unknown.

Comparison of the casts retained by Ramsay in the Australian Museum (of the South Australian specimen) with *Sceparnodon* teeth in the South Australian Museum leaves no doubt that the original of them is South Australian Museum specimen no. P 5018 (see fig. 1, B, D). This tooth was collected in the bed of Salt Creek, Normanville, South Australia (Stirling 1913, p. 140).

P 5018 agrees closely with Owen's figures and with the original casts in the Australian Museum except that today its proximal part has been further broken away. By modern standards, the casts are rather poor but are nevertheless good enough to show that the distal edge of the fossil and its shape agree with them and, in particular, such individual peculiarities as the rugosities in the enamel, its wear facets, and the minor chips in the cutting edge of the tooth, are matched perfectly by similar peculiarities in the casts. This specimen was also figured and described by Stirling (1913, p. 140 and pl. 45, fig. 6, 7); although he used it as a basis for comparison with his specimens of *Phascolonus gigas,* he was not aware that it was one of the syntypes. Its registration number (P 5018) has been given in recent times and there is no original label. The source of it is given as Sir Edward Stirling. Unfortunately, Stirling has given no precise date of collection of this specimen, but says of fossils from Normanville (footnote to p. 162) "as recorded in the Proceedings of the South Australian Royal Society vol. III (Abstract of Proceedings), p. xx, remains of *Phascolonus* were obtained from this locality as early as 1879, some of which are those stated to have been sent to Professor Owen for identification, but the remainder cannot be traced". His statement that specimens from Normanville were sent to Owen cannot refer to any incisors of *Phascolonus* because Owen determined the material and identified it with *Diprotodon, Procoptodon goliah* and *Phascolomys gigas* (Waterhouse 1880); Owen regarded *Sceparnodon* as being distinct from *P. gigas* and would have used that name for

FIG. 1

Comparison of one of the original casts (A, C) of *Sceparnodon ramsayi* Owen with S.A. Mus. specimen No. P5018 (B, D) the designated lectotype.

The occlusal (lingual) surfaces (A, B) show position of wear facets and of individual damage (the specimen seems to have suffered some slight additional damage of the centre of its surface since the cast was taken).

Although the cast is not good by modern standards, sufficient surface texture remains to allow comparison of individual features such as the pattern of enamel ripples (C, D).

A B

C D

incisors. Moreover, had the flat incisor been sent to Owen at that time, it would have reached him before the casts from Ramsay upon which Owen based the name *Sceparnodon ramsayi.*

It is known that collections of fossils were also made from Normanville subsequent to 1879 but beyond a note in Stirling (pp. 161-2) that one of these specimens was a femur of *P. gigas,* it is not known what these comprise. There is certainly no evidence that P 5018 belongs to this later collection, and its agreement with the casts of the syntype is so good that I have no hesitation in deciding that it is the original from which they were made.

There is some confusion over the localities from which Owen's original specimens were collected due to the mention of Gelgoine Station as a locality in Owen's original description. In this, Owen published a paraphrased version of a letter from Ramsay to him in which he describes the teeth to which he had earlier given the generic name *Sceparnodon.* The last sentence of the letter says "those numbered A 3292, A 3295 came from Gelgoine Station . . ." and the implication is that this locality applies to the *Sceparnodon* teeth. However, Mr. J. A. Mahoney (pers. comm.) has established that the specimens sent to Owen from Gelgoine Station are mandibles of *Diprotodon,* and the full text of Ramsay's letter (Ramsay, 1882) makes it clear that it is about a consignment of specimens which comprised more than the flat teeth alone.

Designation of lectotype: The locality from which the incisor tooth specimen no. P5018 in the South Australian Museum was collected is well established and since it (and additional material from Salt Creek, Normanville) formed the basis of comparison between *Sceparnodon* and *Phascolonus* in Stirling's (1913) monograph on *Phascolonus gigas,* I hereby designate no. P 5018 to be the lectotype of *Sceparnodon ramsayi* Owen, 1884.

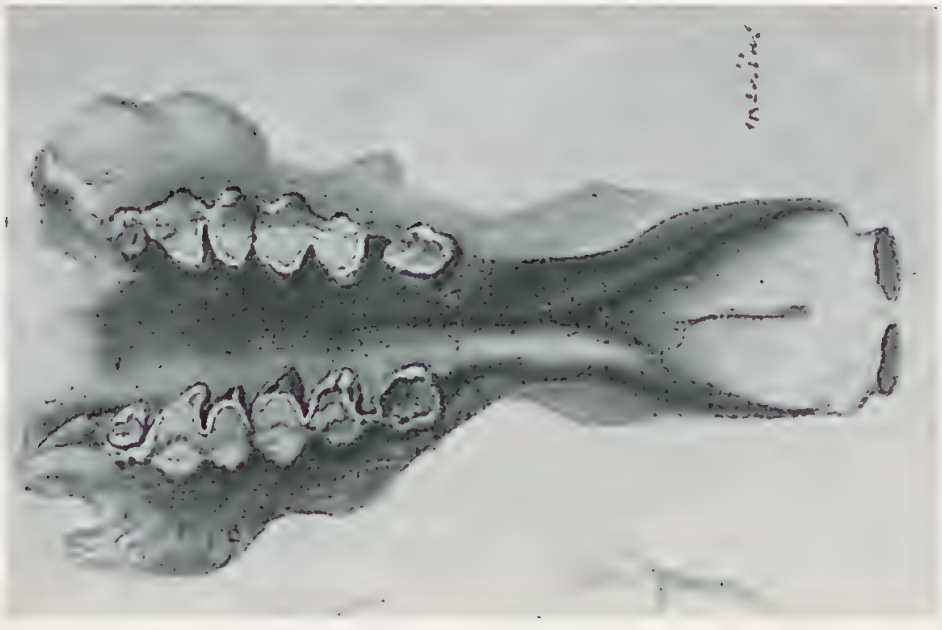
Identity with *Phascolonus gigas* (Owen, 1859): From the time of Krefft's first statement that *Sceparnodon* teeth came from a *Diprotodon,* to the present, there has been considerable discussion as

FIG. 2

A. "*Phascolomys*" *medius*. Owen: to show characteristic flared premaxillary palate common to giant wombats (Specimen Brit. Mus. (Nat. Hist.) no. 32904, from Owen, 1877 *Foss. Mamm. Aust.*, vol. 2, pl. 58, fig. 2).

B. Photographic reconstruction of Stirling's specimen. The maxillary toothrows have been straightened and symmetry restored in the premaxillary region.

C. The palate of Stirling's specimen as restored by Stirling. Displacement of left P4 and M1 towards the midline has not been corrected; the premaxillary region has been poorly restored with plaster and the left incisor inserted.



A

B

C

to whether these strange incisors belong to a wombat or to a diprotodontid (see Ride 1964, p. 125); the argument was thought to have been settled by Stirling who claimed to have found *Sceparnodon* teeth in the skull of the giant wombat *Phascolonus* but, in recent times, Stephenson (1964) has claimed that the premaxillary teeth of Stirling's specimen (which are undoubtedly *Sceparnodon* incisors) do not belong with the maxilla (which is undoubtedly *Phascolonus*). I have examined Stirling's specimen carefully and am satisfied that Stephenson's conclusion is false; the restoration only looks improbable (see fig. 2 C) as a result of the distortion of the maxilla through crushing in the region of the left P^4 M^1. If this section of the maxilla is straightened out (as it is in the photographic restoration presented here, fig. 2 B) the resulting fossil is no more improbable in structure than the premaxilla of any of the other giant wombats (*e.g.*,

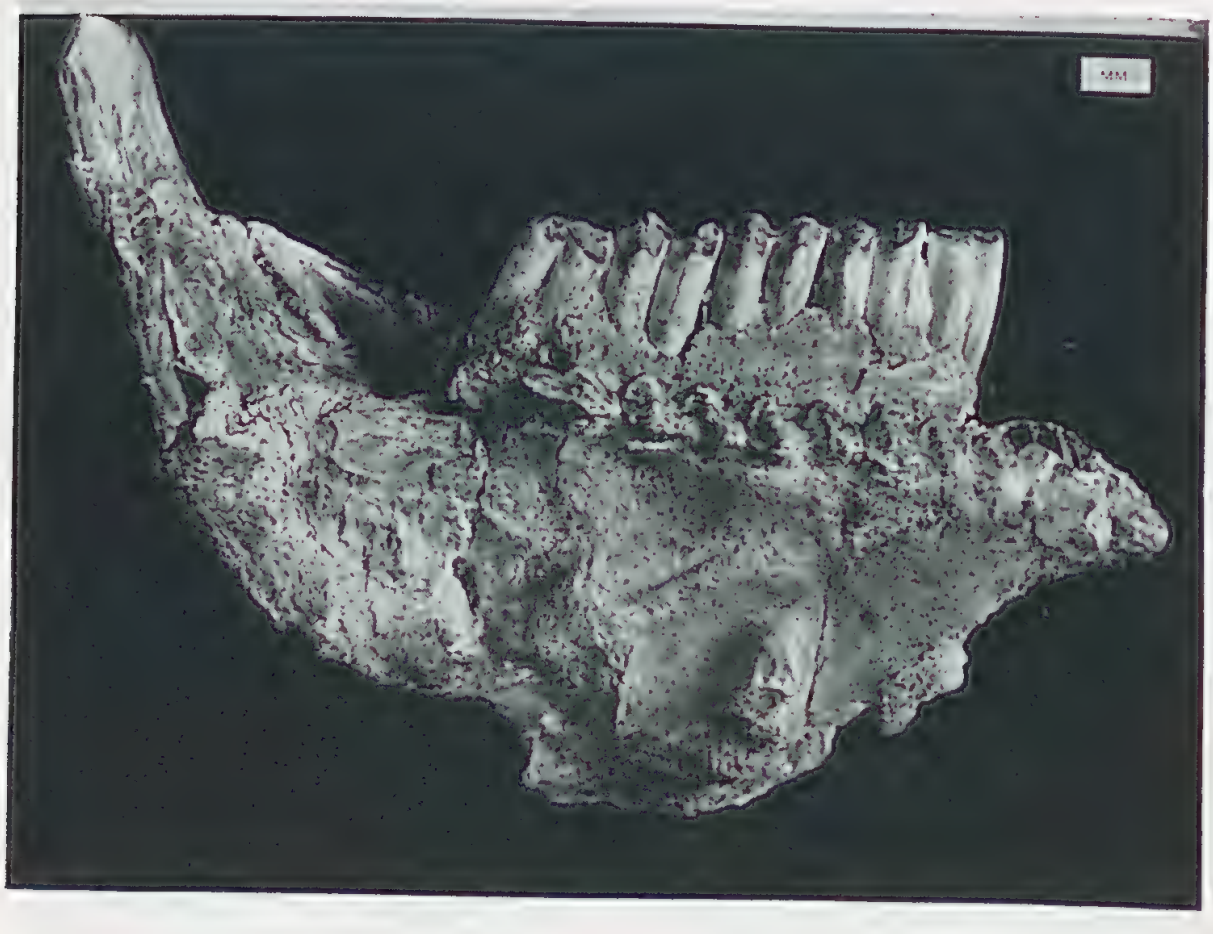


FIG. 3

Stirling's specimen of *Phascolonus gigas* from the right side. The ventral surface is uppermost. Note the continuity of bone from the alveolus of the right incisor through to the maxillary toothrow. Note also the correspondence of the bony ridge on both sides of the fracture which runs vertically from the anterior root of P4 (see insert for detail). The white scale block on the top right hand side of this illustration is 3 mm. wide.

"*Phascolomys*" *medius* Owen; see fig. 2 A) which are characterized by a widely-flaring and deeply-domed premaxillary palate like that of a much-exaggerated *Lasiorhinus latifrons*.

Moreover, if the lateral aspect of the right side of the rostrum of Stirling's specimen be inspected (fig. 3) bone is found to be continuous from the alveolus of the *Sceparnodon* incisor to the maxillary teeth except where the rostrum is fractured through the anterior edge of the premolar. At this point of break, the two edges fit well together and I have no doubt that they are correctly positioned because the bony ridge which marks the position of the buccal-mass is present and continuous on both sides of the break.

REFERENCES

Krefft, G., 1873: *Sydney Mail*, Sept. 6th 1873, p. 302, col. 2.

Lydekker, R., 1887: Catalogue of the fossil Mammalia in the British Museum (Natural History), Part V, p. 158.

Owen, R., 1884: Description of teeth of a large extinct (Marsupial ?) genus. Phil. Trans., 175: 245-248, pl. 11 (numbered 12 in error).

Ramsay, E. P., 1881: Notes and exhibits. Proc. Linn. Soc. N.S.W., 5: 495.

———— 1882: Letter Ramsay to Owen dated 27 Oct. 1881, in *N.S.W. Votes and Proceedings of the Legislative Assembly during the session 1882.* "Exploration of the Caves and Rivers of New South Wales (Minutes, Reports, Correspondence, Accounts)", pp. 37, 8.

Ride, W. D. L., 1964: A review of Australian fossil Marsupials. J. roy. Soc. W. Aust., 47: 97-131.

Stephenson, N. G., 1964: On fossil Giant Wombats and the identity of *Sceparnodon ramsayi*. Proc. Zool. Soc. Lond., 142: 537-546.

Stirling, E., 1913: On the identity of *Phascolomys* (*Phascolonus*) *gigas*, Owen, and *Sceparnodon ramsayi*, Owen; with a description of some of its remains. Mem. Roy. Soc. S. Aust., 1: 127-178.

Waterhouse, F. G., 1880: Exhibits and notes. Trans. Roy. Soc. S. Aust., 3: xx.

A NEW TERTIARY FORMATION AND FAUNA FROM THE TIRARI DESERT, SOUTH AUSTRALIA

(A Contribution from the Museum of Paleontology, University of California, Berkeley)

By R. A. STIRTON[1], R. H. TEDFORD[2], and M. O. WOODBURNE[3]

ABSTRACT

This report describes a new continental formation and vertebrate fauna from the east shore of Lake Ngapakaldi, a salt pan in the central Tirari Desert lying between the Birdsville stock route and the eastern shoreline of Lake Eyre in South Australia. The formation is a stream channel of friable, poorly sorted, pebble conglomerates, and shales cut into folded claystones of the mid-Tertiary Etadunna Formation.

The mammals are mostly woodland kinds, including koala-like, and ringtail and brushy-tail possum-like arboreal forms. A dasyurid, two bandicoots, a wombat, two rat kangaroos, a protemnodont macropodid, and a diprotodontid are also present. Most of the fossils are isolated teeth but there are several well preserved mandibles and numerous foot bones. Four isolated teeth questionably referred to the Monotremata are described. A new genus of wombat and a new genus of koala are proposed.

Other fossils include fish, chelonians, crocodile teeth, a lizard jaw and foot bones of a large emulike bird. Associated with the vertebrate fossils are impressions of *Eucalyptus* leaves and evidence of other plants.

The age of the formation and fossils is tentatively dated as Miocene.

INTRODUCTION

During the past ten years a sequence of middle to late Cainozoic formations and vertebrate faunas have been recognized by the South Australian Museum-University of California Expeditions in the Tirari Desert of the Lake Eyre region in South Australia. A preliminary report on this sequence was presented by Stirton, Tedford and Miller in 1961. The oldest unit is the rather widespread lacustrine Etadunna Formation (see Johns and Ludbrook, 1963) and its Ngapakaldi vertebrate fauna which was tentatively dated as late Oligocene. Following

[1] Museum of Paleontology, University of California, Berkeley.

[2] Department of Vertebrate Paleontology, The American Museum of Natural History, New York.

[3] Department of Geological Sciences, University of California, Riverside.

deposition, the Etadunna and underlying Mesozoic formations were moderately folded by an uplift that is thought to have occurred along an anticlinal axis roughly paralleled by the Marree-Birdsville stock route east of Lake Eyre.

Uplift along the eastern margin of the Lake Eyre basin modified the depositional regime within the basin with the result that stream channel and floodplain sands, silts and clays were superimposed on the folded Etadunna lacustrine deposits. The deposits of the new regime were recognized (Stirton, Tedford, and Miller, 1961) as three formational units, the Mampuwordu Sands, the Tirari Formation, and the Katipiri Sands which probably range in age from late Pliocene through late Pleistocene respectively. It was formerly thought that the relatively long period between the deposition of the Etadunna Formation and the Mampuwordu Sands was not represented by recognizable rock units or by fossil vertebrates in the Tirari Desert.

Evidence of an old stream-channel deposit that falls within this interval was discovered by Paul F. Lawson during the course of field exploration on the 1962 expedition. These deposits, herein described as the Wipajiri[4] Formation, were the subject of a preliminary description by us in 1964. The Wipajiri Formation contains a diverse vertebrate assemblage designated as the Kutjamarpu[5] fauna. Leaf impressions were found in the shales of the upper part of the Wipajiri Formation. Collection of the leaf impressions was hindered by the fact that the damp shales curled upon drying. They also were broken apart by the expansive action of salt crystals which formed on and between the laminae when exposed to the sun and air. We were able to secure a few impressions, however, and these, along with carefeul sketches (fig. 5) made at the outcrop in the field, have been studied by Dr. Harry D. MacGinitie, Research Associate of the Museum of Paleontology. Dr. MacGinitie has kindly permitted us to use the following statement, sent to the senior author in the form of a letter dated February 19, 1965:

"The leaf fossils brought to me by Mr. Michael Woodburne from the Australian locality no. V-6213 on the east shore of Lake Ngapakaldi are clearly the impressions of some species of *Eucalyptus*. Although there is not enough material on which to formally describe a new species, I can definitely say that the identification is without question.

"The impressions are those of lanceolate-falcate leaves, width 2 cm., length 14 cm. (from the drawing made at the site); midrib slender; secondaries numerous, thin, flexuous, arising at angles of 45°, branching and anastomosing near the margin to form a characteristic marginal hem just within the margin; tertiary venation consisting of elongated meshes, the greatest length of the meshes parallel to the secondaries. The leaf is marked by numerous scattered, sclerophyllous dots which are usually seen in the leaves of the living species.

[4] *Wipajiri.* Tirari name for a site along the eastern side of Lake Ngapakaldi, meaning watercourse or stream; approved by the State Nomenclature Committee of South Australia.

[5] *Kutjamarpu.* New faunal name from the Tirari word meaning "many leaves"; approved by the State Nomenclature Committee of South Australia.

"Although it does not seem possible to distinguish the living species of *Eucalyptus* on the basis of their foliage alone, it may be profitable to call attention to the resemblance of the fossil impressions to the leaves of several species of lanceolate-leafed gums such as *E. marginata* Smith, *E. longifolia* Link, or *E. propinqua* Deane & Maiden."

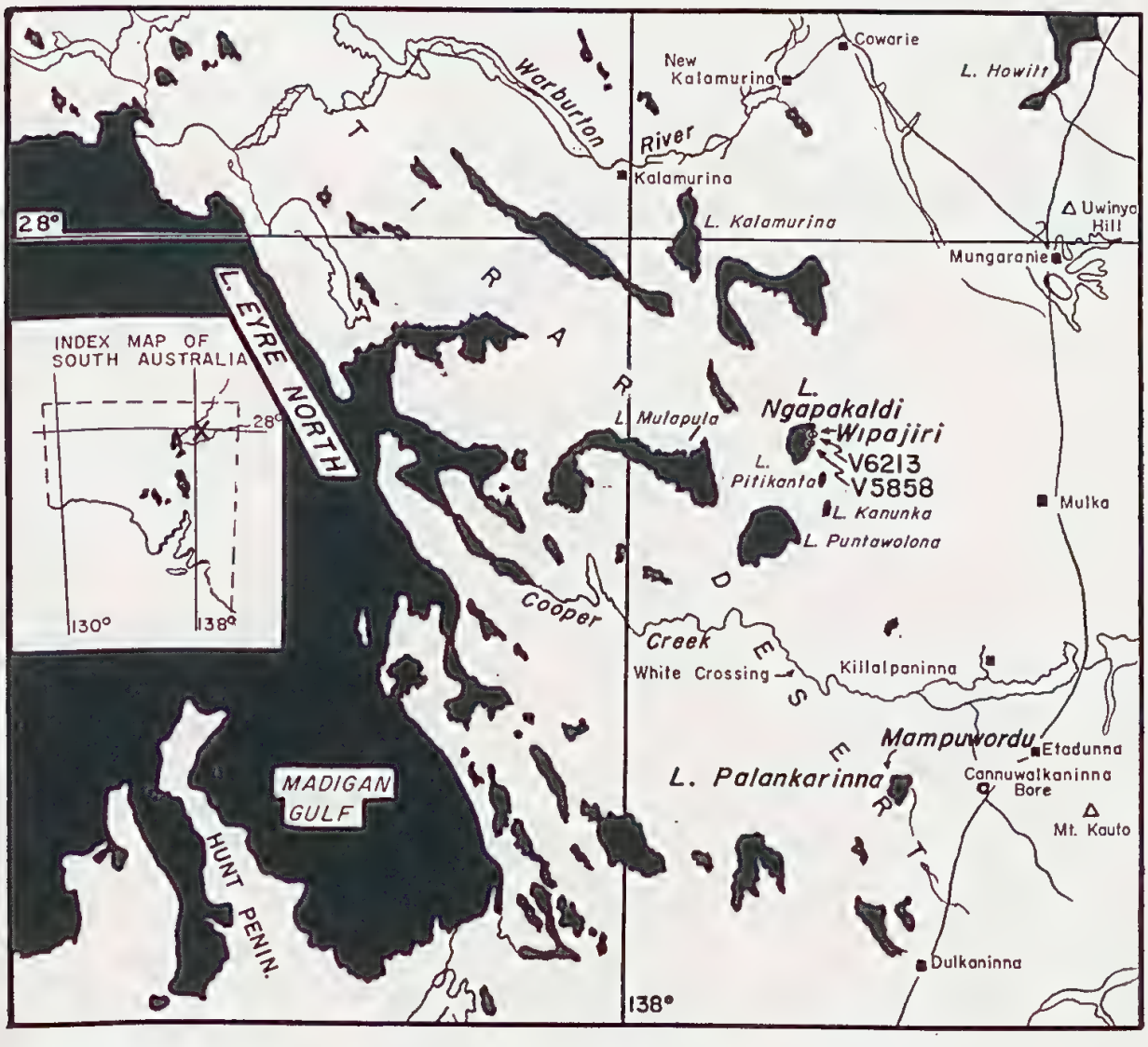


FIG. 1

Map of Tirari Desert, east of Lake Eyre, South Australia. Note position of Lakes Ngapakaldi, Puntawolona and Palankarinna.

Beginning about 1,200 feet north of Locality V5858 on the east shore of Lake Ngapakaldi (fig. 1), ferruginous conglomerates, sandstones and dark grey claystones crop out in an area about 50 feet wide and 900 feet long which follows the northeast trend of the shoreline of the lake (fig. 2). At the south end of the outcrop, the deposits are lost in the gypsiferous silts of the salt pan; to the north they are covered by Quaternary or Recent sand dunes. The Wipajiri Formation

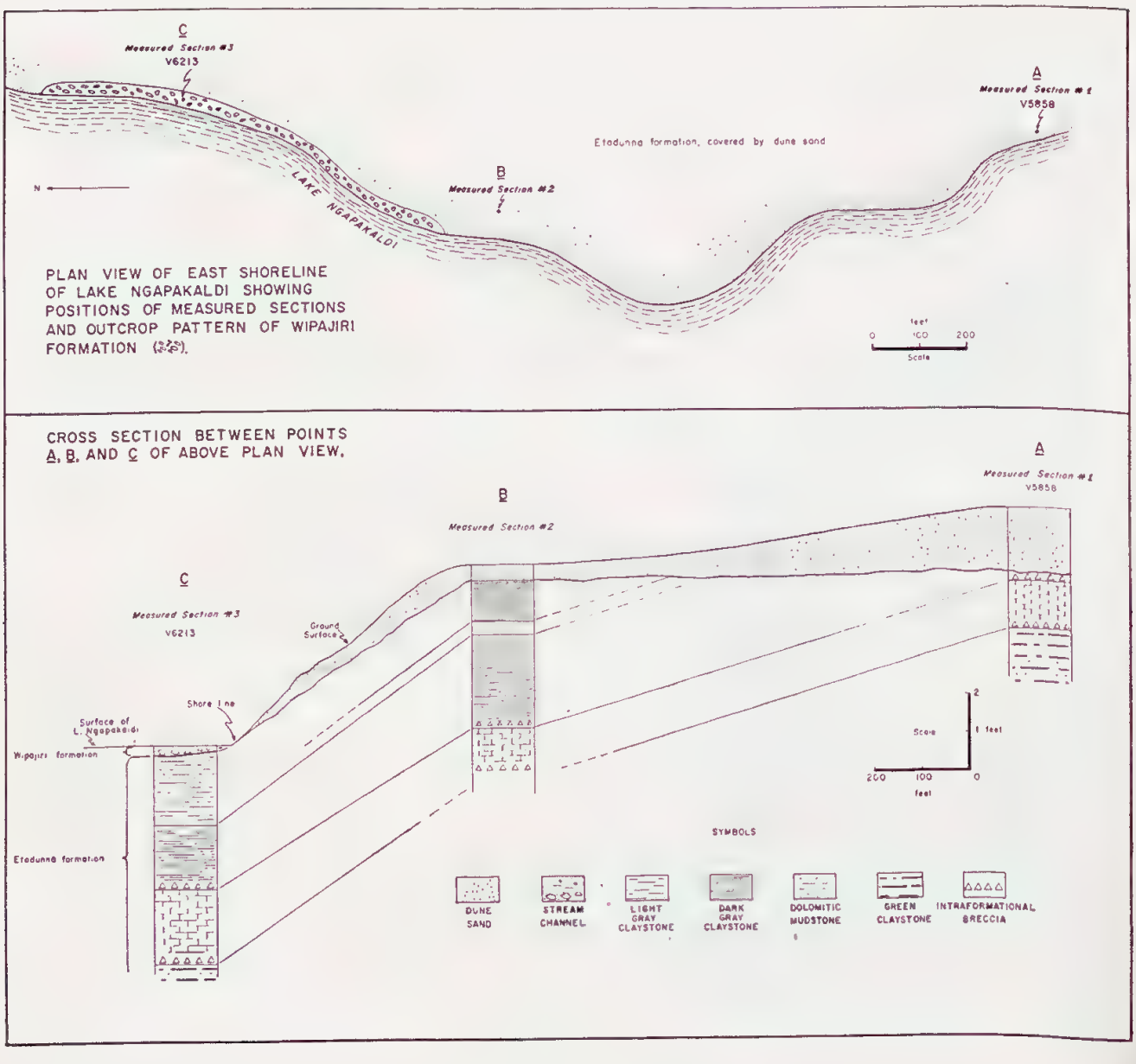


FIG. 2

(Above.) Plan view of east shore of Lake Ngapakaldi between fossil sites V-5858 and V-6213.

(Below.) Cross-section constructed between measured sections 1, 2 and 4 of the above plan view, showing northward dip of Etadunna Formation. Wipajiri Formation is channelled into the Etadunna at V-6213.

occurs in a north-easterly trending stream channel which is cut down into the claystones of the Etadunna Formation. Although the relations between the two formations appear disconformable, a slight angular unconformity is indicated by low angle tilting of the Etadunna Formation (strike N. 30°E., dip 2°NW). There is, however, no evidence for or against the Wipajiri being involved in the tilting, because of the limited extent of the exposure and the nature of the contact between the formations.

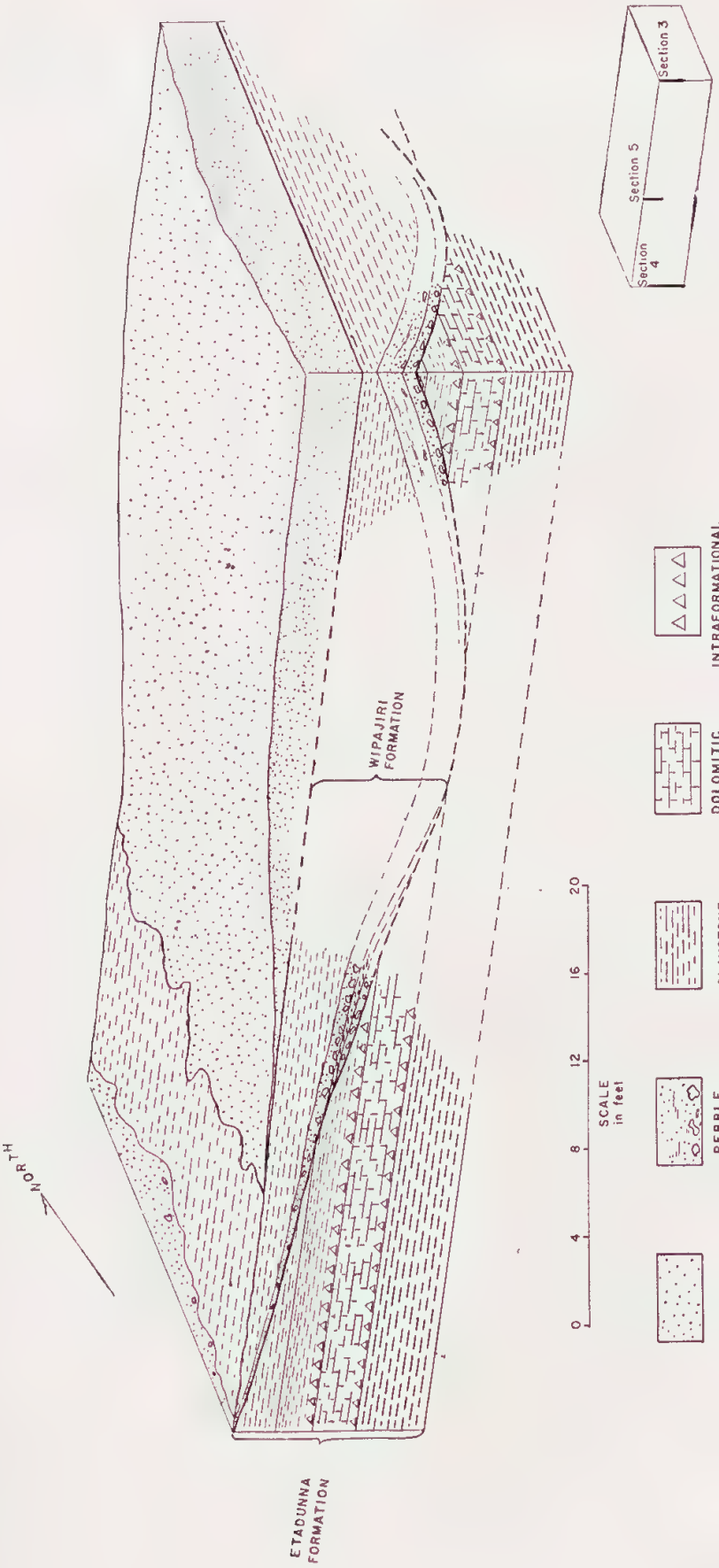


FIG. 3

Block diagram showing Wipajiri Formation channelled into the Etadunna. Small index drawing shows location of measured sections 3, 4 and 5 from which the block diagram was constructed.

The Wipajiri Formation can be subdivided into a basal coarse clastic portion overlain by finely laminated leaf-bearing shales (fig. 12, B). The coarse clastics (units 3 and 5 of measured section 5 in Appendix) contain the vertebrate remains, while the upper shales contain impressions of *Eucalyptus* leaves. The type locality of the formation is at UCMP Locality V6213 (fig. 12, A), 1,835 feet ... 1°E. of Locality V5858 (fig. 2). The outline of the main quarry at V6213 as well as the positions of other pits and measured sections is shown in fig. 4.

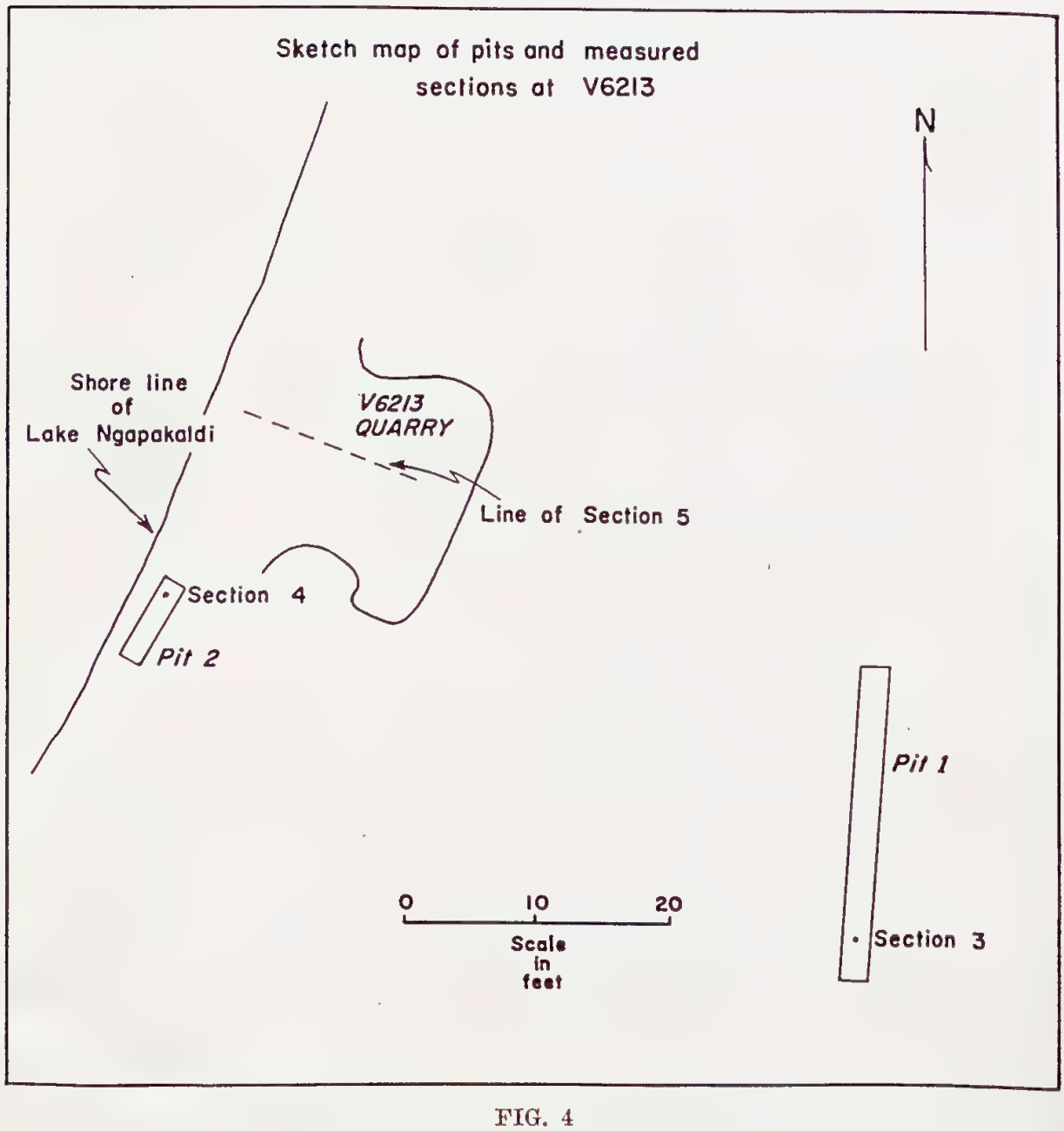


FIG. 4

Diagram showing location of pits. measured sections and outline of main quarry at V-6213.

The lower part of the Wipajiri Formation is composed of a basal conglomerate sequence (see measured section 5, Appendix A). The basal conglomerate is considerably coarser and more heterogeneous than the pebble conglomerate and apparently represents a more youthful stage of erosion with greater competence and velocity of the stream. The first two units are limited to the central part of the channel (see the block diagram, fig. 3) and are truncated by the pebble conglomerate. The latter unit contains the bulk of the Kutjamarpu fauna. The *Eucalyptus*-bearing shales of the upper, finely laminated portion of the formation have also yielded occasional turtle and fish remains in association with lenses of white sand.

Fortunately, the excavation represented by section 4 (fig. 4) is nearly perpendicular to that of section 5 so that the configuration of the channel may be readily seen (fig. 3). The trace of the deepest part of the channel trends about N. 26°E., which may explain the north-easterly trend of the outcrop pattern along the east shore of the lake. Figure 2 shows the northward element of the north-westerly dip of the Etadunna Formation between V5858 and V6213; fig. 2 and 3 show that the Wipajiri is channeled into the light grey and dark grey claystones of the Etadunna Formation. The dip of the Etadunna accounts for the fact that the Wipajiri Formation does not extend down to the fossiliferous green claystone of the Etadunna Formation, even though V6213 is topographically lower than V5858.

The Mampuwordu Sands at Lake Palakarinna represent a later phase of fluviatile deposition in the Tirari Desert. This deposit is composed of relatively clean white sands, light grey lenticular claystones, along with fragments of limestone derived from the Etadunna Formation and shows the following differences when compared with the Wipajiri Formation:

Mampuwordu Sands [Lake Palankarinna]	Wipajiri Formation [Lake Ngapakaldi]
1. Main clastic constituent is quartz sand, white to yellow, with only local centers of limonite stain.	1. Main clastic constituent is quartz sand, clear to amber, but more uniformly covered by limonite stain.
2. Clay occurs mainly as lenses.	2. Clay occurs in more persistent beds.
3. Derived clasts include durierust pebbles, Etadunna limestone fragments, milky quartz pebbles.	3. Derived clasts include durierust pebbles, irregular fragments of chert, ferruginous pebbles and cobbles, pre-Etadunna sandstone pebbles, Etadunna claystone, sandstone and calcareous mudstone pebbles and cobbles.
4. Crossbedding conspicuous and characteristic.	4. Crossbedding not evident.
5. Commonly a gypsum layer at basal contact.	5. No gypsum layer at basal contact.
6. On the whole, finer grained, cleaner, better sorted.	6. On the whole, coarser grained (in basal ⅓), more heterogeneous, less well sorted.

The "dirtier", generally coarser, more heterogeneous character of the Wipajiri Formation in contrast to the Mampuwordu Sands may be explained by a difference in source. The Wipajiri may also represent, at least in its initial deposits, a time of greater stream velocity and competence in a younger stage of erosion due to greater topographic elevation of the source area associated with regional uplift. "Regional uplift is reflected in the change from fine grained clastic and chemical sediments of the Etadunna to the coarser fluviatile deposits of the Mampuwordu Sands . . ." (Stirton, Tedford and Miller, 1961, p. 37). The contrast between the Etadunna and Wipajiri Formations affords the same inference. Also, the Etadunna is tilted at both Lakes Palankarinna and Ngapakaldi, although to a greater degree at the former. "At Lake Palankarinna the Etadunna Formation was folded into a broad syncline before the Mampuwordu Sands and horizontally bedded Tirari Formation were deposited. This folding may have corresponded with movements along the Mesozoic-early Tertiary anticlinal axis immediately to the southeast because the formations overlying the Etadunna are poorly sorted fluviatile deposits rich in fragments derived from a duricrusted terrain" (Stirton, Tedford and Miller, 1961, p. 32). Such an uplifted Mesozoic-early Tertiary anticlinal axis also may have served as the source for the Wipajiri Formation, in which case the terrain between the source and site of deposition (V6213) would have been of sufficient diversity to supply the duricrust and chert fragments, large hematitic clasts, pre-Etadunna sandstone clasts, and large Etadunna green claystone, sandstone and calcareous mudstone clasts found in the basal unit of the Wipajiri.

Nearly all of the larger clasts within the Wipajiri Formation can be traced to sources in the immediate area or regions farther east or southeast. The coarse clastic portion of this formation is made up to a large extent by round pebble to cobble sized clasts of green and grey sandstone and claystone, and white (usually mottled yellow by secondary limonite) calcareous mudstone derived from the immediately underlying Etadunna Formation. The bulk of these clasts are green sandstones and silty or clayey sandstones which do not crop out in the near vicinity and are relatively rare in the known outcrops of the Etadunna Formation. These probably represent basin margin facies of that formation which was being actively stripped when the Wipajiri was being laid down. Other argillaceous Etadunna clasts can be traced to sources at Lake Ngapakaldi or in the near vicinity.

The hard-rock clasts include a variety of rocks most of which have been observed in outcrops in the anticlinal uplifts to the east. These include duricrust fragments and fragments of bleached sandstone. The polished gray duricrust pebbles, often three-sided, are types encountered in the Etadunna Formation, and may have been derived from that formation. The irregular chert clasts and large ferruginous fragments have not been observed in any of the previously described Cainozoic deposits in the Tirari Desert.

The abundant ferruginous clasts resemble laterites in that they are heavy, vesicular, iron-rich (31.0% Fe_2O_3) rocks. They have a granular texture, with grains about the size of a medium to fine sand. This reflects the texture of the parent sandstone because abundant quartz grains of similar size are preserved. These grains seem to be more completely replaced by limonite or hematite in the parts of the clasts which have the reddest colour. The largest ferruginous clasts observed were over 12 inches in maximum dimension, but the average would be only ten inches. Their size indicates that they were derived from a massive outcrop of ferruginous sandstone rather than one with a pisolitic structure. They cannot have been transported far as they are rather soft and yet have retained an irregular subrounded shape.

The only local outcrop known to us in which similar iron-rich rocks are found occurs 10 miles to the south-west along the north-eastern shore of Lake Puntawolona. These deposits are ferruginous mottled fine grained quartz sandstones containing patches which are highly ferruginized. This outcrop seems to be a part of the irregular surface upon which the Etadunna Formation was deposited. Both Etadunna green claystones and fluviatile sands referred to the Katipiri Sands occur in the outcrop at Lake Puntawolona south of the ferruginized remnant, but their relation to the latter is obscured by drift sand. Other such remnants may occur in the vicinity of the Wipajiri type section, now buried under later deposits or exposed in salt pans not yet visited.

The irregular, subangular chert clasts range in size from less than an inch to several inches in longest dimension. They all have a conspicuously fibrous appearance which was at first mistaken for the texture of fossil wood. When broken, they are yellow brown, grey or blue-black and nearly completely replaced by silica, although they often show the remnant fibrous texture of their surfaces. These rocks have not been encountered in outcrop; they may be a primary silica deposit, as a siliceous spring deposit, or replacement of limestone. There is no resemblance to the known chert nodules in the Etadunna dolomitic limestone nor do these siliceous rocks show any trace of remnant calcareous material.

Most of the lithostratigraphic evidence merely indicates that the lower limit to the age of the Wipajiri Formation is post-Etadunna, as is that of the Mampuwordu Sands. Since outcrops of the Mampuwordu Sands occur some 35 miles south of those of the Wipajiri, the relative ages of these formations cannot be determined by physical stratigraphy. At Lake Palankarinna, the Mampuwordu Sands are overlain by the horizontal red argillaceous sandstones and arenaceous claystones of the Tirari Formation. These horizontal deposits also occur at Lake Ngapakaldi but, unfortunately, not in conjunction with the Wipajiri Formation. They are exposed near the top of the bluffs on the western side of Lake Ngapakaldi where they appear to directly overlie the Etadunna Formation (Stirton, Tedford and Miller, 1961, p. 57; note, the words "covered interval" should appear between units 3 and 4 of this section). The Wipajiri is covered only by Quaternary or Sub-Recent sand dunes so that its upper limit is not closely determinable by stratigraphic means. The geologic evidence indicates a post-Etadunna age for the Wipajiri Formation. Preliminary studies on the elements of the Kutjamarpu fauna corroborate this conclusion and further suggest that the Wipajiri is much older than the Mampuwordu Sands.

KUTJAMARPU FAUNA

The type locality of the Kutjamarpu fauna is UCMP Locality V6213, 1,835 feet N. 1° E. of UCMP Locality V5858 on the east shore of Lake Ngapakaldi, South Australia (fig. 1 and 2). The vertebrate fossils occur in the basal clastic portion of the Wipajiri Formation (units 3 and 5 of section 5; Appendix) where they are found as disarticulated skeletal elements. Spines of teleost fish are by far the most abundant, but mammal bones, jaws and teeth are common. The jumbled, disarticulated nature of the fossil remains is consistent with the stream-channel character of the deposit. In view of the relatively

high competence and velocity of the stream suggested by the size range and angularity of the clastic particles, the unabraded nature of the fossil remains indicates that they were derived from the immediately surrounding area rather than being brought in from far away. The

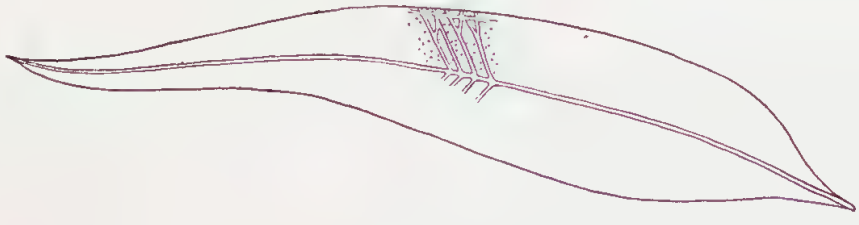


FIG. 5

Drawing of *Eucalyptus* leaf impression from the upper dark shale portion of the Wipajiri Formation at V-6213. One-half natural size.

leaf-bearing shales produced a few complete turtle carapaces and plastra and fish skeletons, and a partially complete lower leg and foot of an emu-like ground bird. These deposits contained the only associated skeletal elements.

The following preliminary faunal list will give an idea of the content of the Kutjamarpu fauna. Because of the preliminary nature of the present study, only a possible monotreme, a new wombat and a new koala will be described now. The diprotodontid, *Neohelos tirarensis,* has been described by one of us in another publication (Stirton, 1967b). The following Kutjamarpu vertebrates will be described at a later date:—Teleostei, parts of skeletons with bones in place, spines; Dipnoi, teeth; Chelonia, three carapaces, plastrons and foot bones; Squamata, mandible; Crocodilia, part of cranium, teeth, vertebrae, dermal scutes; Casuriiformes, part of pelvis, leg and foot bones; Dasyuridae, right mandible; Permelidae, upper and lower molars, and parts of mandibles; Phalangeridae (trichosurine and pseudocheirine), upper molars and mandibles; Potoroinae, maxilla, upper molars, mandibles, incisors, upper molars, lower molars, foot bones.

Class MAMMALIA

Subclass PROTOTHERIA

We have followed the practice of Simpson (1945, 1959, 1960) in retaining the Prototheria in the Class Mammalia. We agree, however, with the principle advocated by Huxley (1958) that any given category of classification should include the form, if known, which is ancestral

to the other taxa of that category. We thus believe that classifications should be formulated in the vertical, or clade, sense in so far as is possible.

Often, however, fossils are so poorly represented or preserved that the generic, familial or even infraordinal ancestor of a particular category cannot be determined. This is certainly true of the mammal-like groups of the Mesozoic. There is promise that the ancestral relationships of most of these groups will be clarified with future discoveries. Evidence from new discoveries, especially from the Rhaeto-Liassic, when adequate, supports the conclusion that most of the Mesozoic orders as well as the monotremes arose from different groups of mammal-like reptiles.

If the class Mammalia is to be restricted in scope we favour including therein the Theria and their Rhaeto-Liassic ancestors. In the meantime it is preferable to maintain the *status quo*.

Order ?Monotremata

Family *Ektopodontidae*, new family

Family diagnosis: That for genus until other genera or species are found.

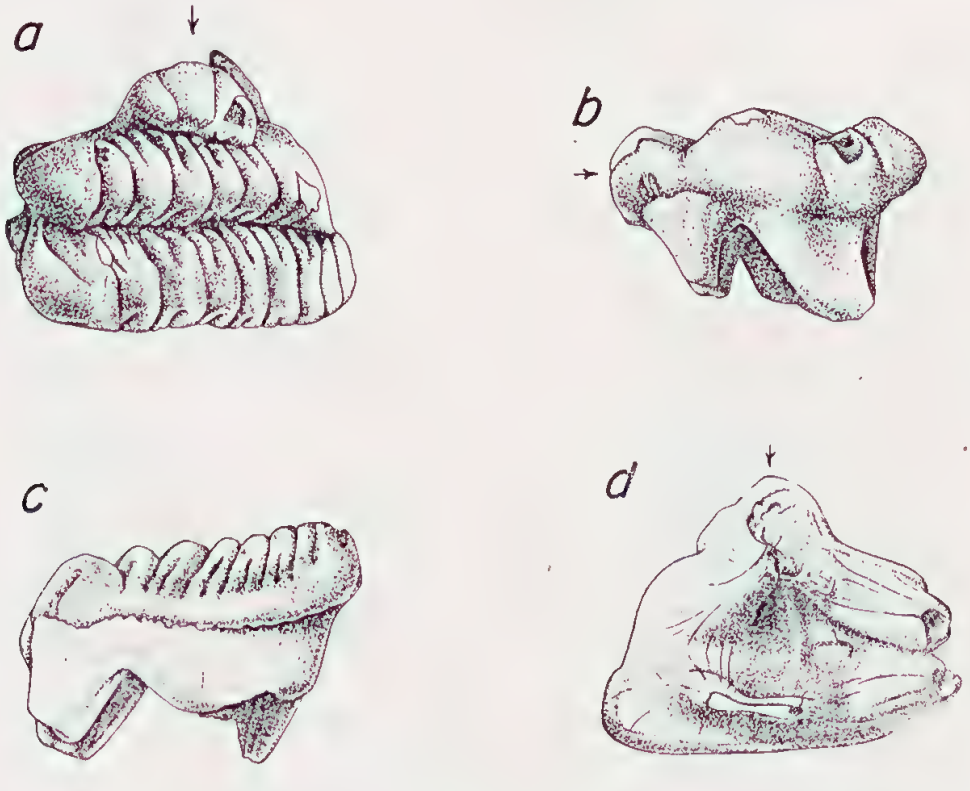


FIG. 6

Ektopodon serratus, n. gen. et. sp. Holotype. *a* occlusal, *b* labial, *c* posterior, *d* ventral views of SAM P13847, left upper molar. Four times natural size. Note appression facette at posterior base of crown. Arrow indicates anterior tip of tooth.

Ektopodon[6] Stirton, Tedford and Woodburne, new genus

(Figs. 6, 7)

Genotypic species: *Ektopodon serratus* Stirton, Tedford and Woodburne, n. sp.

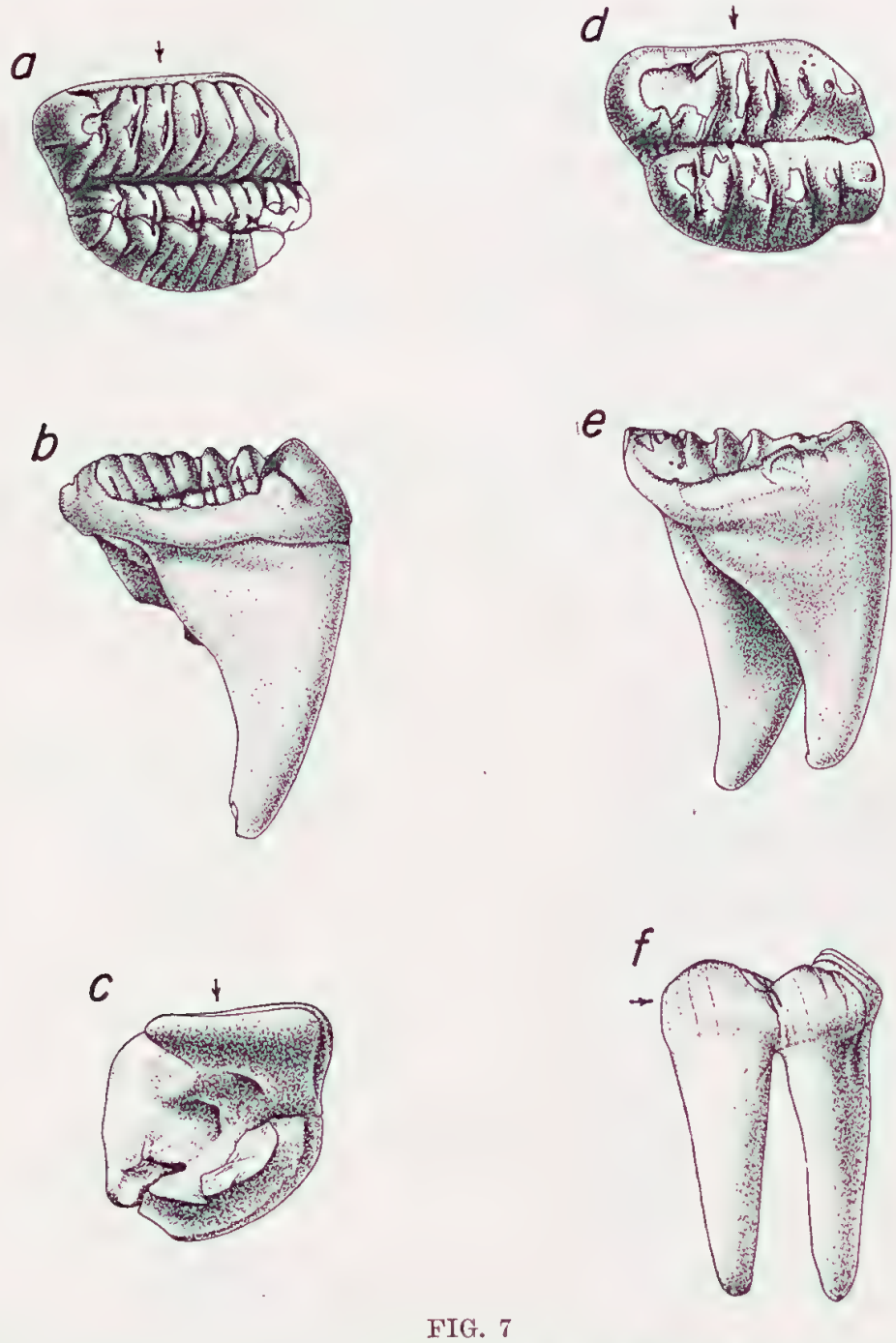


FIG. 7

Ektopodon serratus, n. gen. et. sp. Paratypes. *a* occlusal, *b* anterior, *c* ventral view of UCMP 67173, left lower molar; *d* occlusal, *e* anterior, *f* labial view of UCMP 67174, left lower molar. Four times natural size. Note appression facette at anterior base of crown. Arrow indicates anterior surface of tooth.

[6] κτοπος—odd, strange; and οδοντος—tooth.

Generic diagnosis: Mammals with triangular upper and subquadrate lower teeth of lophodont construction. Lophs (ids) divided into numerous cusps (ids). Basic construction of upper and lower teeth nearly identical. Largest cusp of upper teeth on lingual side of each loph, largest cuspid of lower teeth on labial side of each lophid. Lophs (ids) strongly separated by narrow, deep, transverse valley. Labial and lingual occlusal outline constricted at transverse valley. Roots of lower molars restricted to primary (labial) side of lophids. Upper molars with a labial and lingual pair of roots with a possible additional root under the anterior loph. Lingual pair of roots tend to be fused into a single structure.

Ektopodon serratus[7] Stirton, Tedford and Woodburne, n. sp.

Holotype: South Australian Museum, P13847; left upper molar.

Paratypes: UCMP 67173, unworn left lower molar; UCMP 67174, moderately worn left lower molar; UCMP 67176, well worn right lower molar.

Specific diagnosis: That of genus until other species are described.

Type locality: UCMP Loc. V6213, 1,835 feet north of V5858, east shore of Lake Ngapakaldi, South Australia.

Horizon: Wipajiri Formation; pebble conglomerate, unit 3 of measured section 5 (Appendix).

Age: Kutjamarpu fauna, middle Tertiary; probably Miocene.

Description—Upper molar: The tooth has been oriented as though it were a left upper molar (fig. 6) for reasons which will be developed below. Whether or not this orientation ultimately proves to be correct, it at least serves to facilitate the present description. The length of the tooth, as measured perpendicular to the flat posterior surface is 7.2. The greatest transverse width (8.2) was measured perpendicular to the length. The tips of all roots were either abraded away or broken off.

The occlusal surface of the tooth is widely triangular in outline, with the apex of the triangle directed anteriorly (fig. 6a). A flat, strap-shaped surface is present on the posterior side (fig. 6c). This is interpreted as an appression facette caused by wear against an adjacent tooth in the dental series. A small flattened surface on the anterolabial side of the anterior loph suggests that another tooth was present in the maxillary anterior to SAM P13847. The small size and oblique orientation of the facette indicates that the posterior end of the tooth which caused it would have had a different shape from that

[7] *serratus*—serrate, in reference to the nature of the transverse lophs.

of SAM P13847, and may have been a premolar. Irrespective of which tooth SAM P13847 actually represents, the enamel-covered crown consists of three parallel transverse lophs. The crown is supported by a labial and lingual pair of roots whose basic construction parallels that of the middle and posterior lophs.

The transverse width of the anterior loph is 3.5. It has four crescentically arranged cusps with the second from the lingual side being the largest. The lingual-most cusp slopes laterally against the second cusp. These two cusps are separated laterally and across the crest of the loph by a wide groove; posteriorly the groove is much narrower. The two labial cusps are smaller and more closely appressed. Their features are largely obscured by abrasion of their anterior surfaces.

The second loph is 13.0 wide and is composed of nine cusps. The posterior loph is 13.6 wide and has eight cusps. The largest cusp on each loph is found at the lingual tip of the loph. In occlusal view, the lingual surface of each lingual cusp is strongly convex. The cusps of the middle and posterior lophs are elongate anteroposteriorly, have a blunt, rounded apex, and slant labially from base to tip. The cusps diminish in size labially along each loph to such an extent that the last two are difficult to separate. The anterior and posterior sides of the cusps slope toward the base of the loph at an angle of about 45°, then plunge vertically into the deep, but narrow, transverse groove which separates each loph. The anterior and posterior surfaces of the cusps in the first two lophs slope at about the same angle. In the posterior loph, the posterior side of the cusps is steeper than the anterior. A groove which slants laterally toward the apex is cut into the anterior and posterior sides of most of the cusps. These grooves separate an anterior and posterior pair of root-like ridges on the basal part of each cusp. The grooves terminate just above the bottom of the transverse valley. The anterior faces of the three small cusps at the labial end of the middle loph are united into a smooth surface which is directed anterolingually. The last two labial cusps of the posterior loph also lack grooves, but the commissure between the cusps is still visible. A flat, elongate, strap-shaped facette is developed on the posterior surface of the last loph (fig. 6c). This is similar to facettes on the anterior surface of the lower teeth (fig. 7b, 7d) and is interpreted as an appression facette caused by wear between adjacent teeth.

SAM P13847 has a pair of labial and lingual roots (fig. 6d). The lingual pair slant lingually away from the tooth and are joined throughout their length by an anteroposterior septum. The root-mass thus

formed tapers distally and is reminiscent of the single internal root commonly found in the upper teeth of mammals. The labial root under each loph (fig. 6b) diverges from its lingual counterpart. The anterior labial root is oriented anterolingually toward the anterior tip of the tooth, but also sends off a thin transverse septum toward the base of the anterior lingual root. Most of the root below the anterior loph is broken away. The configuration of the remaining portion suggests that the anterior loph was supported by a single root whose base was connected to the labial root under the middle loph. The posterior labial root is oriented transversely and is composed of a labial and lingual portion. These two parts are mainly swellings in the basic root-mass and are broadly connected by a slightly thinner transverse segment of bone. The root structure thus formed underlies the labial two-thirds of the base of the posterior loph.

Lower molars: The lower molariform teeth are basically like the type specimen with the exception that they have only two transverse lophs and are thus trapezoidal in outline. Except for the short anterior loph of the upper molar, the nearly identical configuration of the upper and lower teeth is striking. UCMP 67173 and UCMP 67174 are illustrated in fig. 7. These two teeth are considered to be left last lower molars because of the appression facettes of their anterior sides and because the greatest development of the roots occurs on the labial side of the teeth. The largest cuspid in each lophid also occurs on the labial side.

The anteroposterior length of the teeth was measured perpendicular to the flat anterior face. The greatest transverse width was measured perpendicular to the length. The height of the roots was taken as the distance perpendicular to a line drawn through the base of the enamel. The measurements for the various lower teeth are as follows: UCMP 67173: anterior length is 5.8, width is 7.2; height of anterior root is 8.0. UCMP 67174: length is 5.8, width is 7.0; height of anterior root is 7.3; posterior root is 7.8. UCMP 67176: length and width of this tooth are approximate because of its extreme stage of wear and a slight amount of displacement along a crack developed in the transverse valley. Length is 5.8, width is 8.0; height of anterior root is 7.4, posterior root is 7.5.

In each tooth there are eight cuspids in the anterior lophid and six or seven in the posterior. UCMP 67176, a right last lower molar, is too worn for an accurate count of its cuspids to be made. Enough of the dental pattern remains, however, to indicate that this tooth had a similar configuration to the others. All of the lower teeth described

seem to come from the same position in the jaw. That UCMP 67176 is from the opposite side of the jaw has already been pointed out.

In UCMP 67173, the grooves on the posterior face of the cuspids on the last lophid extend farther toward the apices than in the upper molar. On the anterior lophid of the lower molars, these grooves are much less developed than in the upper. The anterior and posterior sides of the cuspids slope toward the base at an angle of about 45°. Although UCMP 67174 is in a later stage of wear, the configuration of the cuspids and grooves seem to agree with that in UCMP 67173. Both of these teeth show heaviest wear on the side which we have oriented as labial. This is also the side of the tooth on which the heaviest development of the roots occurs.

In labial view, the main axes of the two roots are essentially parallel, although they curve slightly anteriorly (fig. 7f). In anterior view (fig. 7b, e) it can be seen that the tip of the anterior root is almost directly under the labial edge of the tooth whereas the greater lingual curvature of the posterior root causes its tip to lie in a more medial position. There seems to be no significant difference in the sizes of the two roots.

The basic plan of the lower teeth is a pair of transverse lophids which have been subdivided by a number of cuspids. The orientation of the roots which support the lophids is also transverse (fig. 7c). Like the upper tooth, the lower molars of *Ektopodon* are transversely lophodont, although the coalesced lingual pair of roots in the upper molars may indicate that such lophodonty developed from a basically triangular tooth.

Affinities: The structure of the teeth of *Ektopodon* is not paralleled in any rodent known to us. The geologic and paleozoogeographic setting of the Australian continent indicates, therefore, that the ancestors of this unusual animal should be sought among the Monotremata, Marsupialia, primitive Placentalia, or even earlier groups. Based on the present study and those of Butler (1939), Green (1937), Patterson (1956) and Simpson (1928, 1929a and b) the configuration of the molars and roots of various therian and nontherian groups may be summarized as follows:—

Tritylodontidae: Teeth not tribosphenic; cusps arranged in longitudinal rows; more rows in upper teeth; upper and lower teeth basically similar; either four or five roots in upper teeth, two in lowers; lower roots lie directly under the crown of the tooth; posterior lower root larger than anterior.

Triconodonta: Teeth not tribosphenic; cusps arranged in longitudinal rows; upper and lower teeth basically similar; only two equal roots in either upper or lower teeth; lower roots lie directly under the crown of the tooth.

Multituberculata: Teeth not tribosphenic; cusps arranged in longitudinal rows, more rows in upper teeth; upper and lower teeth of basically similar construction; upper and lower teeth with two roots; lower roots lie directly under the tooth crown; lower roots variable, generally equal in size.

Symmetrodonta: Upper teeth triangular, lower teeth slightly so; cusps arranged in triangular fashion; upper and lower teeth relatively similar; two, possibly three, roots in upper teeth, two in lowers; lower roots lie directly under the tooth crown; posterior root large in upper and lower teeth.

Ektopodon: Teeth not tribosphenic; cusps arranged in transverse lophs; construction of upper and lower molar crown nearly identical; upper molar with three (?four) roots, lowers with two; lower roots developed primarily on labial side of tooth; lower roots essentially same size.

Ornithorhynchus: Teeth degenerate; generally an anterior and posterior moiety separated by a transverse valley, upper teeth with prominent lingual cusp from which one or two ridges pass transversely to the labial side, lower teeth with prominent labial cuspid in each moiety which tends to be elongated into a transverse crest; upper and lower teeth basically similar; embryological studies suggest that each moiety is supported by a transverse root.

Docodonta: Upper teeth transversely rectangular; lowers longitudinally rectangular; cusps basically in longitudinal rows with secondary transverse orientation; three roots in upper teeth, two in lowers; upper and lower teeth different; lower roots lie directly under the crown; lower roots equal sized.

Pantotheria: Teeth tribosphenic; cusps arranged in triangular fashion; upper and lower teeth different; three roots in upper, two in lower teeth; lower roots lie directly under the crown; posterior lower root smaller than anterior.

Meta- and Eutheria: Teeth tribosphenic; cusps arranged in triangular fashion; upper and lower teeth different; three roots in upper, two in lower teeth; lower roots lie directly under the crown; lower roots generally equal in size.

Tritylodontids, triconodonts and multituberculates possess dentitions with low-crowned non-tribosphenic teeth in which the cusps are arranged in longitudinal rows. The upper and lower teeth of these forms are of basically similar construction. The fact that tritylodontids have been classed as reptiles (Romer, 1956) emphasizes the general similarity of the dentition of animals near the reptile-mammal transition. Although appearing later in time than the others, the multituberculates retained this primitive type of dentition. The two-rooted condition of the upper and lower molars found in the triconodonts persisted into the symmetrodonts, although there is a possibility that the latter tended to develop three-rooted upper teeth in the Cretaceous (Patterson, 1956, p. 11).

The symmetrodonts, contemporaneous with the tritylodontids and triconodonts, departed from the basic dental pattern by developing teeth in which the cusps had a triangular orientation. Their upper and lower molars were, however, still basically similar.

At first glance, the docodont dentition seems to represent a rather radical departure from the primitive mammalian type. A strongly transverse, rather than longitudinal, orientation is given to the teeth by the development of transverse crests in the molars, one in the uppers, two in the lowers. Upon closer inspection (see Simpson,

1929a, pls. XVIII-XX) it is apparent, however, that docodont molars consist basically of two longitudinal rows of cusps with secondary cross-crests. The cross-crests descend from each side toward a median longitudinal valley; lophodonty is at best incipient. It is also apparent that the basic construction of the upper and lower molars is similar. The addition of a median longitudinal emargination in the anterior and posterior end of the docodont lower molar would produce a configuration essentially like that of the upper. The development of three roots in the upper molars is a possible advance over the condition in triconodonts and symmetrodonts, and the incipient transverse lophodonty is unique among Mesozoic mammals.

The Pantotheria, Metatheria and Eutheria seem to be too advanced to be considered for the ancestry of *Ektopodon*. The Mesozoic and early Cainozoic members of these groups clearly have tribosphenic molars which do not even remotely resemble those of *Ektopodon*. It is true that some marsupials and placentals have developed transversely lophodont dentitions, but not ones in which the upper teeth are as similar in detail to the lowers or in which the anterior loph is so nearly identical to the posterior.

The most reasonable statement that can be made concerning the ancestors of *Ektopodon* is that they are not presently known. The general degree of advancement shown by its dentition suggests that *Ektopodon* represents a pre-therian lineage. Although no reptile has been known to develop teeth like these, the possibility of basal relationships with the mammal-like reptiles cannot be definitely excluded on present evidence. The development of three-rooted upper molars and the incipient transverse lophodonty found in the Docodonta form a basis for interesting speculations, but the long interval of time involved dictates that these remain mere speculations.

Ancestry of the Monotremata: The origin and phyletic position of these animals, so clearly mammalian in some respects and so obviously reptilian in others, has long been a taxonomic problem. *Tachyglossus* is unfortunately excluded from this discussion by its lack of dentition. The transient molars of *Ornithorhynchus* have been most recently discussed by Simpson (1929b) and Green (1937). From figures and descriptions in these two works it is clear that *Ornithorhynchus* teeth consist of an anterior and posterior moiety separated by a transverse valley. In the upper teeth there is a labial and lingual constriction at the transverse valley. Simpson (1929b) has provided a detailed description of the *Ornithorhynchus* cheek teeth.

Simpson (*ibid.*, p. 7) considered that the teeth were basically composed of two transverse halves, each with a primary lingual upper and lower labial cusp, and that the numerous accessory cusps had no particular significance other than indicating the degenerate nature of the teeth. After reviewing various possibilities Simpson (*ibid.*, p. 14) concluded that the teeth of *Ornithorhynchus* were probably not derivable from any known mammalian type, that the only even remotely possible exception to this might be the triconodonts. A similar conclusion was reached by Green (1937, p. 404) except that he favours the Haramiyidae (Microcleptidae) as a possible ancestor. It is interesting to note that a sufficient number of longitudinal and transverse elements are present in docodont molars to form the structural basis for the teeth of both *Ektopodon* and *Ornithorhynchus*.

Ektopodon and *Ornithorhynchus* both have a simple lophodont dentition in which the largest cusp is located on the lingual side of each upper loph, the labial side of each lower lophid. Embryological studies suggest that if any orientation of the roots in *Ornithorhynchus* can be said to be preferred, it is transverse (Green, 1937, fig. 14). There is also a random proliferation of secondary roots due to the degenerate nature of the teeth. The condition of the lower roots in *Ektopodon,* in which the fang is restricted to the labial or primary side of the tooth, may be attributed to the possibility that the dentition of this animal was becoming degenerate. The nearly random proliferation of cuspules in the teeth of *Ornithorhynchus* may indicate that the teeth had degenerated from a dentition in which cuspules were present, but in a more regulated configuration. Such a configuration could have resembled the transverse proliferation of cuspules seen in *Ektopodon.*

In summary, the molariform teeth of both *Ektopodon* and *Ornithorhynchus* have a simple, bilophate structure which is not closely approached in any other group of mammals. The teeth of *Ektopodon* represent a structural pattern from which the degenerate dentition of *Ornithorhynchus* could be derived. In view of the rather limited data now available it is possible that *Ektopodon* and *Ornithorhynchus* are members of separate, collateral, lineages and are not related orthogenetically. If *Ektopodon* is a monotreme it is the first Tertiary record of the order and points to the long expected but unrecorded diversity of the group. The level of structural development of the dentition in *Ektopodon* and *Ornithorhynchus* is reminiscent of that found in the Docodonta and suggests that the Monotremata originated from non-therian rather than therian mammals.

Subclass THERIA
Infraclass Metatheria

Order **Marsupialia**
Phascolarctidae

Litokoala[8] Stirton, Tedford and Woodburne, n. gen.
(Fig. 8)

Genotypic species: *Litokoala kutjamarpensis* n. sp.

Generic diagnosis: M^1: smaller and labial outline more convex than in *Phascolarctos*, length and width 5.7; space between metacone and hypocone greater than between paracone and protocone; small anterolingual and posterolingual crests ascending from apices of

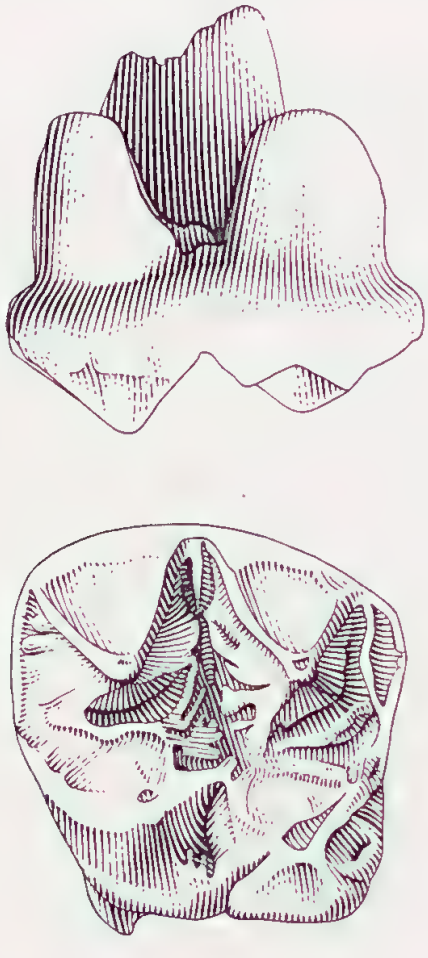


FIG. 8

Labial and occlusal view of RM^1 of *Litokoala kutjamarpensis*, SAM P13845, Kutjamarpu fauna. Approximately two-thirds natural size.

[8] λιτος and *Koala*, to emphasize the relatively simple occlusal pattern of the holotype in comparison with *Perikoala* and *Phascolarctos*.

paracone and metacone; labial cingulum not extended across base of metacone; posterior spur of protoconule directed posterolingually toward transverse valley where it fades out in posterior part of wide longitudinal valley between paracone and metacone; low crest continuous from anterolabial corner of protoconule along anterior base of paracone to labial cingulum; crescentic metaconule present; enamel surfaces moderately crenulate between anterior spurs of metaconule, and on posterior base of paracone; elsewhere in longitudinal and transverse valleys enamel surface smooth.

Litokoala kutjamarpensis[9] Stirton, Tedford and Woodburne, n. sp.

Holotype: South Australian Museum, P13845; right upper first molar in early stage of wear. We have identified this tooth as M^1 on the basis of the following features which are similar to that tooth in *Phascolarctos*. Crescentic anterior cingulum; anterior cingulum continuous with protoloph lingually, widely separating paracone from anterior edge of tooth; metacone slightly higher than paracone, and hypocone higher than protocone; cingulum continuous across labial base of metacone; crescentic stylar structure at anterior base of protocone which forms small pocket in that area.

Specific diagnosis: That of genus until other species are described.

Type locality: UCMP Loc. V6213, 1,835 feet N. 1° E. of V5858, east shore of Lake Ngapakaldi, South Australia.

Formation: Wipajiri Formation; pebble conglomerate, unit 3 of measured section 5 (Appendix).

Age: Kutjamarpu fauna, middle Tertiary; probably Miocene.

Description: The Kutjamarpu tooth is smaller than in *Phascolarctos*; its greatest length and width is 5.7. The four principal cusps are prominent and pyramidal in outline. Although the protocone is more worn it seems clearly to have been lower than the hypocone[10]. The relative heights of these cusps also prevail in M^1 of *Phascolarctos*; however in the living koala the cusps are equal in height or nearly so on M^2, but the reverse is true on M^3 and M^4 where the paracone and protocone are higher than the metacone and hypocone. In the Kutjamarpu M^1 the distance between the metacone and hypocone is greater than between the paracone and protocone; the reverse is true

9 In reference to the occurrence of the species in the Kutjamarpu fauna.

10 Hypocone is used here only in a topographic connotation. Homology with cusps in a similar position on upper molars of some placental mammals is not implied. In another genus from the Kutjamarpu fauna the evidence seems clear that the cusp in question is developed from the posterior wing of the protocone, rather than from a cingulum or as a twinning of the protocone as has occurred in most placental mammals.

throughout the tooth row in *Phascolarctos*, and probably *Perikoala*. The triangular labial surfaces of the paracone and metacone in P13845 slope gently to the apices of the cusps.

Other distinctive characters in the Kutjamarpu M^1 indicating phascolarctid affinities are seen in the anterolingual and posterolingual crests ascending from the apices of the paracone and the metacone. In *Phascolarctos* only the posterolingual crest of the paracone is present. These crests do not occur in *Schoinobates* or *Pseudocheirus*.

The pattern of attrition on the molars is apparently the same in both *Litokoala* and *Phascolarctos* in that the anterior and posterior edges of the paraselene and metaselene contribute equally to the shearing function of the tooth. In *Pseudocheirus* and *Schoinobates* most of the shearing is done by the posterior crests of those selenes.

The labial outline of the Kutjamarpu tooth, in direct occlusal view, is somewhat more convex than in M^1 of *Phascolarctos*. The sloping labial surface opposite the paracone is narrower and more concave anteroposteriorly than the surface opposite the metacone. Furthermore the base of the paraconal surface is crossed by a cingulum, whereas that of the metacone is unobstructed. *Phascolarctos* differs in having a cingulum across the base of each of these surfaces in M^1. In *Pseudocheirus* and *Schoinobates* the cingulum on the paraconal surface is incomplete because a groove passes from the middle of the surface to the base of the tooth. The metaconal surface of those genera also differs in that a crest ascends posterodorsally from mesotyle II so that the surface is unobstructed only at its posterolabial corner.

The stylar cusps in *Litokoala* are not as prominent as in *Phascolarctos* and can be seen best by their triangular outline from the labial side. The parastyle, as in *Phascolarctos*, is far back from the anterolabial corner of the tooth and is connected to the paracone by the anterior wing of the paraselene. In M^1 of both *Pseudocheirus* and *Schoinobates* the parastyle is at the extreme anterolabial corner of the tooth and is separated from the base of the paracone by a deep cleft.

In *Litokoala*, the stylar cusps decrease slightly but progressively from the parastyle to the metastyle, whereas in *Phascolarctos* the height of the styles on M^1 in descending order are mesostyle II, mesostyle I, parastyle and metastyle.

The protoconule is separated from the protoloph in *Litokoala* and occurs at the anterolingual base of the paracone. The posterior spur of the protoconule is directed posterolingually toward the transverse valley where it fades out in the posterior part of the wide

longitudinal valley between the paracone and metacone. In *Schoinobates* and *Pseudocheirus* the spur is relatively longer, crescentic, and is connected to the posterolingual base of the paracone. *Phascolarctos* also differs from the Kutjamarpu tooth in having a short crescentic spur that connects to the anterolingual base of the paracone. A low crest is continuous from the anterolabial corner of the protoconule along the anterior base of the paracone to the labial cingulum. This structure is not seen in the koalas we have for comparison. In M^1 of *Pseudocheirus* the protoconule is connected directly to the parastyle, whereas in *Schoinobates* it first joins the anterior cingular extension of the protoloph which continues on to the parastyle. The surface of the protoconule in the Kutjamarpu tooth is smooth whereas in *Phascolarctos* ridgelets and grooves between them give a rather boldly crenulate effect to the conule. A low but distinct ridgelet extends posteriorly from the protoloph in the lingual side of the longitudinal valley.

A structure identified by us as a modified metaconule occurs as a very low crescentic crest medial to the lingual base of the metacone. Its posterior spur extends back into the valley between the metacone and the hypocone but is closer to the metacone. This structure is not present in *Phascolarctos* or in the M^2 of *Perikoala*. Anteriorly the metaconule in the Kutjamarpu specimen divides into two spurs. One extends anterolabially into the transverse valley between the metacone and paracone, but does not reach as far labially as in *Schoinobates* or *Pseudocheirus*. The other spur is directed anterolingually and is separated from the junction of the metaloph crest of the protocone and the anterolabial crest of the hypocone by a narrow groove. In *Litokoala* there is a short transverse ridgelet connecting the metaconule with the anterolabial crest of the hypocone. The enamel surface between the anterior spurs of the metaconule, on the labial surface of the junction and on the posterior basal surface of the paracone, is crenulate; but elsewhere in the longitudinal valley between the main cusps, the enamel surface is smooth. This is in marked contrast to *Phascolarctos* and *Perikoala* in which the longitudinal valley is deeply crenulate.

The protocone and the hypocone are much more widely rounded in the Kutjamarpu tooth than in *Perikoala* and *Phascolarctos*, consequently the anterior and posterior wings of those selenes do not stand out as sharply in relief in *Litokoala*. Another phascolarctid character is the connection of the metaloph crest of the protocone and the anterolabial crest of the hypocone. This closes the transverse valley area lingually well in from the inner edge of the tooth. In

Schoinobates and *Pseudocheirus* the posterior of these crests bypasses the anterolabial crest of the hypocone. A rather bulbous cusplike structure occurs at the anterolingual base of the hypocone. It connects across to the base of the protocone forming a pocket between it and the crest formed by the junction of the metaloph crest of the protocone and the anterolabial crest of the hypocone. The cusplike structure is subdued in *Phascolarctos*, and its connection across to the protocone is more cingulumlike, is longer and fades out at the lingual base of the protocone. These features are even more subdued in *Pseudocheirus* and *Schoinobates*. Both *Litokoala* and *Phascolarctos* have a short stylar structure at the anterolingual base of the protocone. It, however, is more crescentic and forms a deeper pocket in the fossil. In

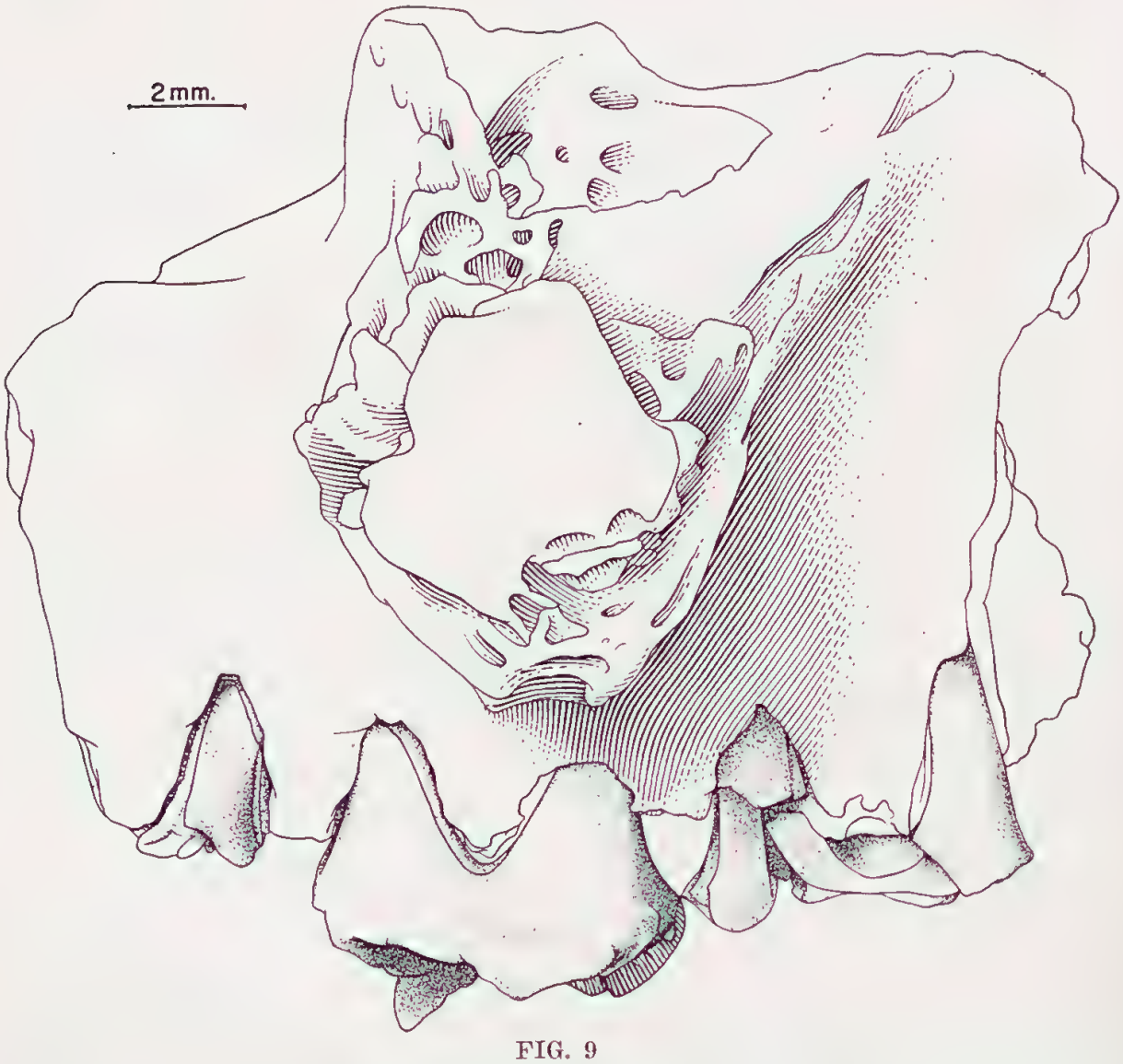


FIG. 9

Labial view of right maxillary fragment of *Perikoala palankarinnica*, UCMP 45343. Approximately two-thirds natural size.

Phascolarctos this feature diminishes progressively from M^1 to M^4. It is not present in *Pseudocheirus* or *Schoinobates,* and is apparently absent in *Perikoala.*

Paratype of Perikoala palankarinnica: The paratype of *Perikoala palankarinnica* from the Etadunna Formation is a right maxillary fragment (UCMP 45343) with a partial alveolus of P^3, roots of M^1, M^2 with the crown partly preserved and an alveolus of M^3 (figs. 9, 10).

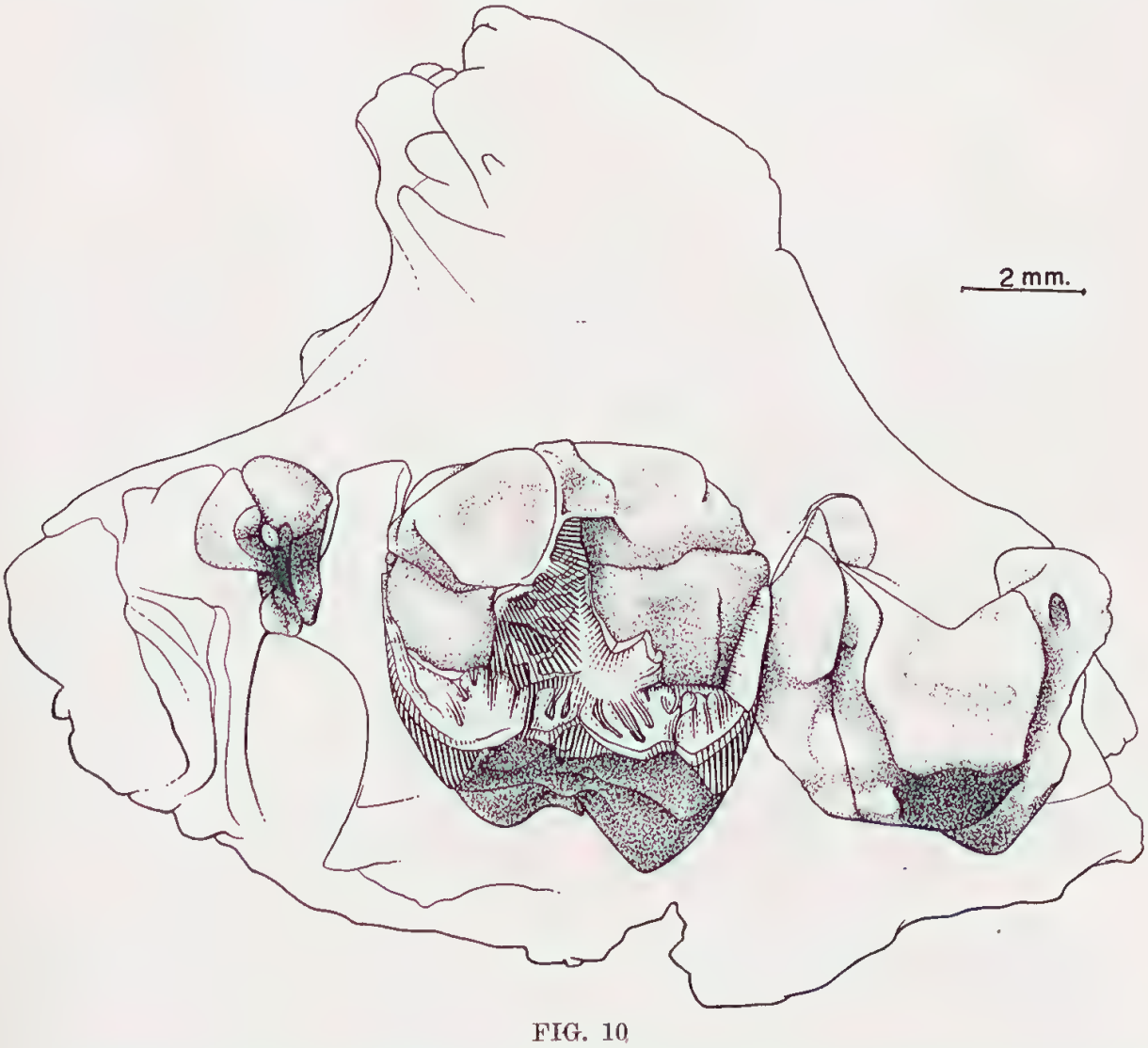


FIG. 10

Occlusal view of right maxillary fragment of *Perikoala palankarinnica,* UCMP 45343. Approximately two-thirds natural size.

Nearly all of the body of M^2 is present, only the lingual cap is absent from the paracone and the posterolingual face of the metacone. The unobstructed labial surface of the metacone and the absence of the metaconule agree with the M^2 of *Phascolarctos.* Although most of the lingual base of the paracone is missing, there is no suggestion on the remaining portion that an anterolingual stylar cusp was present.

This suggests further agreement with M^2 of *Phascolarctos* as compared with M^1. The length and width of the tooth are both approximately 5.9.

The tooth is essentially unworn as far as can be seen, which may to some extent account for the profusely crenulate nature of the crown enamel. The enamel appears to have been smooth on the lingual surfaces of the hypocone and protocone, and is smooth on the labial surface of the metacone; but on the labial surfaces of the protocone and hypocone and the anterior surface of the metacone and adjacent areas, the enamel is strongly crenulated. The distribution and intensity of crenulation equals that of comparably worn specimens of the koala and is thus different to the condition in *Litokoala*.

In *Litokoala* and in *Phascolarctos*, a ridgelet extends posteriorly from the protoloph in the lingual side of the longitudinal valley. In *Perikoala*, the *function* of a raised structure in this area of the tooth is maintained by a series of transverse ridgelets directed labially from the protocone and protoloph. Each of these ridgelets terminates abruptly at the axis of the longitudinal valley in a small, raised conule. A line connecting the apices of these terminal conules passes posteriorly from the protoloph in a similar orientation and position as does the protoconule ridgelet in the Kutjamarpu tooth and in *Phascolarctos*. In RM^1 and LM^3 and LM^1 of two specimens of *P. cinereus* at hand, the configuration seen in *Perikoala* is present; whereas in the other molars of those two specimens, as well as all the molars of two other Recent specimens, a ridgelet is present. This suggests that the condition in *Perikoala* is a variation upon a functional plan, and may also indicate that the *function* is as important as the *means* by which it is achieved. The lack of this ridgelet in *Perikoala* in contrast to the condition in the other animals does not necessarily remove *Perikoala* from the direct ancestry of *Phascolarctos*.

The labial border of the tooth as seen in occlusal view is oblique anterolabially, which suggests that the transverse diameter across the anterior half of the tooth was greater than that across the posterior half. This agrees with the condition in M^2 of *Phascolarctos* and differs from *Litokoala* in which the transverse diameter across the respective parts of the tooth is essentially the same. This may be due to the fact that the Kutjamarpu tooth is M^1. M^1 in *Phascolarctos* is more nearly equidimensional transversely across the anterior and posterior halves than M^2.

In *Perikoala* and *Phascolarctos*, a metaconule is not present as a distinct cusp, the enamel being highly crenulate in that area. On the other hand, the presence of a distinct metaconule in *Litokoala* is in

direct contrast to this and it may represent a primitive feature which has been retained from an earlier level of organization.

The metaloph in *Perikoala* curves smoothly from the protocone posterolabially to meet the anterolabial crest of the hypocone. This is more typical of M^2 than M^1 of *Phascolarctos* in which the posterior arm is directed posterolabially and then turns abruptly labially before joining the arm from the metaconule.

Except for its smaller size those parts of the tooth which can be compared in *Perikoala* agree with M^2 of *Phascolarctos*. The only significant similarity to *Litokoala* is size but the more complex enamel crenulations and the absence of the metaconule tend to preclude close affinity between *Perikoala* and the Kutjamarpu form, although both may have had some pre-Ngapakaldi common ancestor.

In ventral view, the anterior root of the zygoma in *Perikoala* lies directly above M^2, its anterior surface slopes smoothly on to the maxillary above M^1 and its posterior face is concave posteriorly. In lateral view, the labial edge of the anterior face is directed anterodorsally, not vertically as in *Phascolarctos*. The root of the zygoma is essentially symmetrical in lateral view in that the anterior and posterior surfaces slope equally toward each other and meet ventrally so that a sagittal section through the root would be triangular, with the apex ventral. In *Phascolarctos*, the anterior surface is vertical while the posterior surface slopes anteroventrally. Thus, a sagittal section through the root would be asymmetrical with the apex of the triangle shifted anteriorly. *Phascolarctos* possesses a ventral boss at this apex which is oriented anterolingually in ventral view, is thickest medially and tapers laterally and posterodorsally along the lateral surface of the arch. The zygoma in *Phascolarctos* occupies the maxillary from above the midpoint of M^1 to the rear of M^2, its anterior face possesses a strong antorbital fossa below the infraorbital foramen.

As compared to that of *Phascolarctos*, the anterior root of the zygomatic arch in *Perikoala* is smaller both longitudinally and transversely, has no ventral boss, is more symmetrical in the sagittal plane, apparently lacks a concave antorbital fossa below the infraorbital foramen, and the anterior face slopes anterodorsally in lateral view rather than being vertical. All of these characters point to the more primitive nature of *Perikoala*, and may be related functionally to the *masseter* being less well developed in *Perikoala* as compared with *Phascolarctos*.

Remarks: As discussed by Stirton (1957), the lower dentition of *Perikoala* is more primitive than *Phascolarctos*, and a similar statement can be made concerning the fragmentary upper tooth described

above. It seems clear, however, that *Perikoala* and *Phascolarctos* are more closely allied than either is to *Litokoala*. The latter apparently represents a persistently primitive side branch which diverged, at some point in the early Tertiary, from the lineage leading toward *Phascolarctos*. On the other hand the basic similarity of *Phascolarctos*, *Perikoala* and the Kutjamarpu form shows that these animals represent a major phyletic branch, possibly within the Phalangeroidea excluding *Pseudocheirus* and *Schoinobates*. At the present time, the most reasonable taxonomic assignment of the latter two genera seems to be with the Phalangeridae.

TABLE OF MEASUREMENTS

	Phascolarctos cinereus				*Litokoala*	*Perikoala*
	UCMP	UCMP	UCMP	UCMP	SAM	UCMP
Lengths	71665	58801	58800	22814	P13845	45343
RM1	8.1	7.5	7.9	7.8	5.7	
LM1	8.3	7.4	7.8	7.9		
RM2	7.8	7.8	8.0	7.6		5.9*
LM2	7.8	7.8	7.9	7.9		
Widths						
RM1	8.2	7.8	7.7	7.8	5.7	
LM1	8.1	7.8	7.7	7.8		
RM2	8.4	7.9	7.9	7.7		5.9*
LM2	8.2	7.8	8.0	7.9		

* Approximate.

Vombatidae

Rhizophascolonus[11] Stirton, Tedford and Woodburne, n. gen.

(Fig. 11)

Genotypic species: *Rhizophascolonus crowcrofti* Stirton, Tedford and Woodburne, n. sp.

Generic diagnosis: P^3: bilobed; anterior lobe round, enamel on lingual and labial sides; posterior lobe 3.8 wider transversely than long anteroposteriorly; enamel on rounded lingual side, absent on labial side; from edge of enamel posteriorly occlusal outline curves obliquely anterolabially then around into labial inflection; shallow opposing lingual and labial inflections; height of enamel about 16.1 above root on lingual side, on anterolabial side 4.3; one small labial and two well developed lingual roots.

Rhizophascolonus crowcrofti[12] Stirton, Tedford and Woodburne, n. sp.

Holotype: South Australian Museum P13846, moderately worn left P^3.

[11] ριζοφάσκωλονος—in reference to the rooted character of the holotype in comparison with teeth of *Phascolonus*.

[12] In honour of Dr. W. P. Crowcroft, Director of the South Australian Museum.

Specific diagnosis: That of genus until other species are described.

Type locality: UCMP Loc. V6213, 1,835 feet north of V5858, east shore of Lake Ngapakaldi, South Australia.

Horizon: Wipajiri Formation; pebble conglomerate, unit 3 of measured section 5 (Appendix).

Age: Kutjamarpu fauna, middle Tertiary; probably Miocene.

Description: This family is represented by a left upper P^3 that is clearly referable to a new genus. It differs markedly from the living and Pleistocene wombats in having one small labial and two well developed lingual roots, and in the height of the crown.

The crown is bilobed as emphasized by shallow labial and lingual inflections. The anterior lobe is essentially round; its transverse width is 7.5. The transverse dimension of the posterior lobe is 10.6, whereas anteroposteriorly it measures 6.8. Although the inner half of the posterior lobe is uniformly rounded, from near the posterior midline the outline curves obliquely anterolabially then around into the labial inflection. This part of the occlusal outline is accentuated by the absence of enamel on the side of the tooth in that area. Otherwise a 1.0 layer of enamel starting at the labial inflection extends around the anterior lobe into the lingual inflection where it is very thin, then continues around the lingual side of the posterior lobe to terminate on the posterior surface.

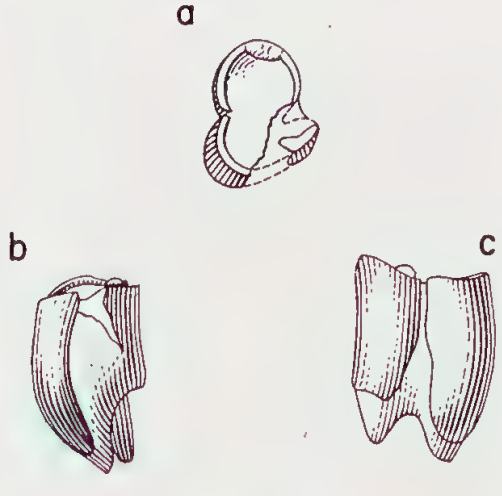


FIG. 11

Rhizophascolonus crowcrofti, n. gen. et. sp. *a* occlusal view, *b* posterior view, *c* lingual view of holotype, LP^3. SAM P13846. Natural size.

One of the most interesting features is a small, liplike, remnant of enamel that folds back from the anterior edge over a small part of the otherwise extensive exposure of dentine. The remaining enamel is slightly grooved at the midline with higher points on each side.

This bit of enamel therefore is suggestive of an enamel covering of the occlusal surface at and near this level. If so, the height of crown of the tooth in a young animal was little if any higher than in the tooth at hand.

The tooth is curved labially and has the greatest exposure of enamel on the lingual surface. Below the anterior root on the lingual side the enamel measures 11.8, and below the posterior root it is 16.1, whereas on the labial side of the anterior lobe the enamel height is 4.3.

The lingual inflection widens from about 0.8 at the edge of the occlusal surface to 4.0 at the base of the enamel. This inflection is largely filled with cement which coalesces with the dentine of the roots dorsally. The roots are partly abraded but their tapering outlines indicate that the longest one was not more than 7.0 in length.

Remarks: The distribution of the enamel and dentine in the occlusal pattern, the labial curvature and the apparent incipient hypsodonty of its P^3 indicate that *Rhizophascolonus* is a wombat.

The bilobed outline and the size of the premolar seems to reveal that *Rhizophascolonus* is more closely related to *Phascolonus* than to *Ramsayia, Lasiorhinus* or *Vombatus*. The lobes of P^3 in *Phascolonus* are of different shape than in *Rhizophascolonus*; there is no enamel on the labial side of the anterior lobe, and the tooth is extremely hypsodont and rootless. *Ramsayia* and *Lasiorhinus* differ from the other wombats in having P^3 with a triangular occlusal outline and in lacking either a labial or lingual inflection, but as in *Phascolonus*, enamel is absent on the labial side of the anterior lobe. In *Vombatus* the occlusal outline is nearly triangular but there is an anterolingual groove and the enamel encircles the tooth.

If *Rhizophascolonus* is ancestral to *Phascolonus*, the rate of evolution in hypsodonty is much like that which occurred in the development of the Pleistocene beaver *Castoroides* from *Monosaulax*, which lived during the Miocene, even though the increase in tooth size in the beaver lineage is much greater than in the wombats.

Evidence from the P^3 of *Rhizophascolonus* seems to indicate that the *Phascolonus* lineage extended well back into the Miocene if our correlations are reasonably correct. Therefore, the common ancestor for all of the known genera of wombats may have lived well back in the Oligocene.

A

B

FIG. 12

A. View from lake of UCMP loc. V-6213, type locality of Kutjamarpu fauna and Wipajiri Formation. Quarry is at edge of lake; tractor is standing on dune deposits.

B. Closer view of Wipajiri Formation at V-6213 showing coarse dark basal clastic deposits overlain by lighter, thinly bedded leaf-bearing shales. Dip of beds indicate channel configuration. Shovel is approximately horizontal. White 6in. ruler shows scale.

ENVIRONMENT

As indicated in the faunal list the Kutjamarpu is one of the most diverse Tertiary vertebrate faunas yet uncovered in Australia. The large number of forest dwelling types indicates that the stream in which the Wipajiri Formation was deposited passed through a wooded area. This is consistent with the setting implied by the abundant impressions of *Eucalyptus* leaves found in the upper portion of the formation. The riparian situation represented by the Wipajiri Formation and its contained fossils indicates the former presence of climates which were more hospitable than those which now obtain in this part of Australia.

AGE OF THE KUTJAMARPU FAUNA

The peramelids, phascolarctids and macropodids have their closest affinities with forms in the Ngapakaldi fauna. The wombat is more primitive than any known Pleistocene or Recent member of the family. The ancestral position of *Neohelos tirarensis* to *Kolopsis torus* from the late Miocene Alcoota fauna of the Northern Territory (Stirton, Woodburne, and Plane, 1967), strongly points to a Miocene age for the Kutjamarpu fauna. On the present evidence, the best estimate of the age of the Kutjamarpu fauna is post-Ngapakaldi and pre-Alcoota, probably closer to that of the Ngapakaldi fauna. The Wipajiri Formation was thus deposited after the Etadunna Formation and before the Mampuwordu Sands. The Wipajiri is the second oldest formation in the five-fold stratigraphic succession of Tertiary rocks in the Tirari Desert and, as compared with the age assignments given to the other faunas in the area, is probably Miocene in age.

APPENDIX A

Measured Section 1

At UCMP Locality V5858, North-east shore, Lake Ngapakaldi; type locality of Ngapakaldi fauna. (See fig. 2.)

Unit	Description	Thickness
1	*Gypsiferous drift sand,* orange red	18in.
UNCONFORMITY		
ETADUNNA FORMATION		
2	*Claystone,* dark grey; arenaceous particles sparsely distributed throughout. "Greasy" appearance on freshly broken surface. Basal intraformational breccia.	3in.
3	*Claystone,* dolomitic, light grey. "Greasy" texture on fresh surface. Basal intraformation conglomerate of green claystone fragments.	15in.
4	*Claystone,* grey green to green with scattered fine grained quartz sand and silt. Fossil mammals at top (UCMP Locality V5858), *Ngapakaldi fauna.* Base not exposed.	15in. +
		51in +

Measured Section 2

1,165′ N. 8° W. of V5858 (see fig. 2)

Unit	Description	Thickness
1	*Gypsiferous drift sand*; orange red	3in. +
UNCONFORMITY		
ETADUNNA FORMATION		
2	*Claystone*, dark grey; arenaceous particles sparsely distributed throughout. Freshly broken surface has "greasy" appearance.	13in.
3	*Claystone*, light grey, slight greenish tinge; lacks "greasy" appearance on fresh surface.	4in.
4	*Claystone*, dark grey, as unit 2, but possibly slightly higher fraction of arenaceous particles. "Greasy" appearance on fresh surface. Basal intraformational breccia 6in. thick consisting of a lighter grey claystone matrix enclosing angular to subrounded particles of light calcareous mudstone (unit 5) and a dark grey claystone. Thin (½in.) layer of gypsum variably separating units 4 and 5.	30in.
5	*Claystone*, calcareous (dolomitic), light grey. "Greasy" texture on fresh surface. Scattered occasional particles of both lighter mudstone and dark brownish grey claystone. Basal contact with underlying green claystone (fossiliferous at V5858) indicated by intraformational conglomerate of rounded to subrounded particles of pebble and coarse sand sized fragments of the green claystone. Total depth not reached.	12in. +
		62in. +

Measured Section 3

In 24ft. long pit (Pit 1) trending N. 4° E., whose N. end is 49′ S. 68° E. from centre of main quarry (V6213) of *Kutjamarpu fauna*. See fig. 4.

Unit	Description	Thickness
1	*Dune sand*	30in.
UNCONFORMITY		
WIPAJIRI FORMATION		
2	*Shale*, dark grey, thinly laminated, with scattered gypsum crystals. Leaf remains. 5ft. to north the bed thickens to 30in. Lenses of well sorted angular white sand grains are interbedded in lower part in association with turtle remains. (Corresponds with unit 2, section 5.)	9in.
3	*Claystone*, dark green, with ferruginous partings; scattered gypsum fragments, clay pebbles and rounded duricrust fragments occur throughout. Larger claystone pebbles found near base (probably corresponds to unit 3, section 5).	12in.
4	*Claystone*, light green, highly limonitic	1in.
5	*Pebble conglomerate*, green claystone, light calcareous mudstone and light grey claystone clasts of Etadunna formation in light grey claystone matrix. Local centres of limonite stain and gypsum crystals interspersed. Selenite near base. Main fossil concentration; numerous remains of fish, turtle, crocodile and occasional mammals (probably corresponds to part of unit 3, section 5).	5in.

Unit	Description	Thickness
UNCONFORMITY		
ETADUNNA FORMATION		
6	*Claystone to siltstone*, light grey; "greasy" when wet (probably corresponds to unit 2, section 4).	2 to 6in.
7	*Claystone*, limonite stained	1in.
8	*Claystone*, calcareous, dark grey. Base not reached. (Probably corresponds to unit 3, section 4.)	6in. +
		66in. +

Measured Section 4

North end of pit 2, 14′ S. 29° W. of centre of V6213. See fig. 4

Unit	Description	Thickness
WIPAJIRI FORMATION		
1	*Sandstone*, brown, ferruginous, with green claystone and limonitic pebbles; gypsum partings. Thickens to north-east (corresponds to unit 3, section 5).	2in.
UNCONFORMITY		
ETADUNNA FORMATION		
2	*Claystone*, light grey, with scattered fine sand-sized arenaceous particles. This apparently combines units 2 and 3 of section 2.	24in.
3	*Claystone*, dark grey, with basal intraformational breccia consisting of angular to subrounded fragments of light calcareous mudstone and darker brown claystone in matrix dark grey claystone.	20in.
4	*Claystone*, light grey, calcareous (dolomitic); green intraformational breccia at base.	24in.
5	*Claystone*, green. Same as fossiliferous unit at V585. Base not exposed.	4in.
		74in.

Measured Section 5

Along line a-b (fig. 4) in main quarry of *Kutjamarpu fauna* (V6213) 1,835ft. N. 1° E. of type locality of *Ngapakaldi fauna* (V5858). See fig. 4 and fig. 12, A.

Unit	Description	Thickness
1	*Dune sand*	6in.
UNCONFORMITY		
WIPAJIRI FORMATION		
2	*Shale*, dark grey, finely laminated, containing plant remains. Limonitic stain at base. Occasional arenaceous partings with limonite stain, and lenses of fine sand with green clay balls or arenaceous green clay associated with turtle remains.	31in.
3	*Pebble conglomerate*, rounded green, occasionally blue, claystone clasts, with scattered ferruginous sandstone clasts (smaller size than in unit 5), rounded durierust fragments, irregular siliceous clasts. Upper 2in. ferruginized. Main vertebrate fossil horizon of *Kutjamarpu fauna*.	7in.

4	*Claystone*, blue, with scattered large green claystone clasts and limonite concretions and pebble-sized green and brown claystone clasts. Contains impressions of unionid pelecypods and vertebrate remains.	3in.
5	*Conglomerate*, pebble to boulder sized clasts, mainly rounded green sandstone, claystone and subrounded red ferruginous sandstone fragments in a limonite coated sand matrix. More angular light to dark grey claystone clasts derived from underlying Etadunna formation. Scattered rounded durierust clasts and angular fragments of chert. Conspicuous large turtle fragments usually standing on edge. Contains fish, reptile and mammal remains.	4in.
UNCONFORMITY		
ETADUNNA FORMATION		
6	*Claystone*, light grey, base not reached	
		51in.

BIBLIOGRAPHY

Butler, P. M., 1939: The teeth of the Jurassic mammals. Proc. Zool. Soc. Lond., B. 109: 329-356, 12 figs.

Green, H. L. H. H., 1937: The development and morphology of the teeth of *Ornithorhynchus*. Phil. Trans. Roy. Soc. Lond., B. biol. ser., 228: 367-420, 14 figs. 18 pls.

Johns, R. K. and Ludbrook, N. H., 1963: Investigation of Lake Eyre. Geol. Surv. S. Australia, report of invest. no. 24: 1-104, 17 figs.

Patterson, B., 1956: Early Cretaceous mammals and the evolution of mammalian molar teeth. Fieldiana: Geol., 13, 1: 1-105, 17 figs.

Romer, A. S., 1956: The Osteology of the Reptiles. Chicago: Univ. Press. xxi + 772 pp., 248 figs.

Simpson, G. G., 1928: A catalogue of the Mesozoic mammalia in the geological department of the British Museum, London. British Museum (Nat. Hist.), x + 215 pp., 12 pls.

——— 1929: American Mesozoic Mammalia. Mem. Peabody Mus., 3, pt. 1, pp. i-xv + 171, 62 figs. 32 pls.

——— 1929b: The dentition of *Ornithorhynchus* as evidence of its affinities. Amer. Mus. Novit. no. 390: 1-15, 2 figs.

Stirton, R. A., 1955: Late Tertiary Marsupials from South Australia. Rec. S. Aust. Mus., ix, 3: 247-268, 11 figs.

——— 1957a: Tertiary Marsupials from Victoria, Australia. Mem. Nat. Mus. Vict., 21: 121-134, 6 figs.

——— 1957b: A New Koala from the Pliocene Palankarinna Fauna of South Australia. Rec. S. Aust. Mus., xiii, 1: 71-81, 2 figs.

——— 1967a: The Diprotodontidae from the Ngapakaldi fauna, South Australia. Bull. Bur. Min. Resources no. 85.

——— 1967b: A diprotodontid from the Miocene Kutjamarpu fauna, South Australia. *Ibid.*

Stirton, R. A., Tedford, R. H., and Woodburne, M. O., 1964: A new Tertiary fauna from the Tirari Desert, South Australia (Abstract). Geol. Soc. Amer. Spec. Pap. no. 82: 281-282.

Stirton, R. A., Woodburne, M. O., and Plane, M. D., 1967: A phylogeny of the Tertiary Diprotodontidae and its significance in correlation. Bull. Bur. Min. Resources no. 82.

Dr. R. A. Stirton died suddenly on June 14th, 1966 while this paper was in press. This great loss is keenly felt for "Stirt" was a person of rare ability, enthusiasm and generosity and an inspiration to all who knew him. The inquiry into the history of the Australian mammals had been one of his major interests for over a decade and it is largely through his stimulus that much of the present knowledge concerning the Tertiary vertebrates of that continent has been brought to light. Our association with Dr. Stirton on these and other studies has been a thoroughly enjoyable and rewarding experience and it is our intention to carry on, as far as possible under the circumstances, the Australian projects he initiated.

R. H. Tedford and M. O. Woodburne.

A REVIEW OF THE STARFISH GENUS NECTRIA (ASTEROIDEA; GONIASTERIDAE)

By S. A. SHEPHERD

SUMMARY

The asteroid genus *Nectria* is reviewed in the light of recent collections and a new species, *N. saoria,* from southern Australian seas is described. Notes upon the morphology, ecology and distribution of each species are included together with a key for the genus.

INTRODUCTION

The characteristically Australian genus *Nectria* Gray is widely distributed in southern Australian seas ranging from the Abrolhos Islands in Western Australia to Norah Head on the New South Wales coast. Sladen (1889, p. 318) also reports a specimen from Fiji.

Six species have been described, one of which is endemic to New Zealand. All the species are benthic and limited to shelf waters. Until recently the paucity of specimens has severely impeded a knowledge of the genus with the result that the task of separating the species has not been easy. Clark (1946, p. 85) summarized the knowledge of the genus and gave a key. Recent dredgings, and particularly the advent of the aqualung, have enabled biologists to collect better series of specimens, and to observe their environment and habits. It is now possible to dispel some of the confusion with which the genus has been bedevilled since the time of the early inadequate descriptions of some species.

In this paper the taxonomic relationships between the Australian species are examined and the results of a study of the specific characters for each are given. One new species from South Australia is described and the variation in the other species is discussed. A key is supplied and photographs of typical forms added to make their recognition easier and to assist future workers. The author records his observations upon the ecology and distribution of the species in southern Australian seas.

The collections of the Queensland Museum, Australian Museum, National Museum of Victoria, Hobart Museum, South Australian Museum and Western Australian Museum have been examined and the following abbreviations are used for them respectively: Q.M., A.M., N.M.V., H.M., S.A.M., and W.A.M.

Nectria ocellifera (Lamarck)

Asterias ocellifera, Lamarck (1816), p. 553.

Asterias ocellifera, Oudart, pl. 1 (1815).

Goniodiscus ocelliferus, Muller and Troschel (1842), p. 60.

Nectria ocellifera, Dujardin and Hupe (1862), p. 406.

In 1963 and 1964 the *Diamantina* dredged extensively in Western Australian shelf waters between 21° and 33° South Latitude. As a result seven specimens of this little known species were taken, all between 31° and 33° South in 120-200 m.

Although the locality of origin of the type is not known it now seems probable that it was taken in Geographe Bay, Western Australia by Peron and Le Sueur who dredged there in 1801. (Peron 1812, pp. 53, 83.)

For many years writers have been perplexed by the similarity of this species to *N. ocellata* (Sladen 1889, p. 319 and Mortensen 1925, p. 293). Clark (1914, p. 139 and 1916, p. 34) however felt little hesitation in recognizing each species on the basis of the Endeavour specimens of 1912 and the recent material amply confirms his opinion and establishes this as an endemic species of the deeper shelf waters of Western Australia.

There is little difference between the specimens which range in size from juveniles in which R = 37 mm. to adults in which R = 61 mm. and the distinctive characters of the species are well marked. The disk is large and the rays short as indicated by the R/r ratio which in adults is 2.5, and in juveniles 2.9 to 3. The granulation upon the aboral disk tabulae is unique. The peripheral granules are large, tending to be flattened and form a radiating fringe about the tabula. In several specimens the peripherals protrude obliquely outwards so as to give a saw-toothed appearance to the tabula. The inner granules are quite different in character and are flattened and extremely low, being raised above the tabula by not more than 0.1 mm. They may be circular or somewhat polygonal but not crowded. Pedicellariae are absent. Orally the spines of the adambulacral or oral armature have little tendency to be prismatic. As Oudart's Plate is not available either in the Paris Museum or the British Museum (Nat. Hist.) (pers. comm. A. M. Clark) the species is figured here for the first time.

Material examined. W.A.M.: 2 specimens numbered 4914 between Fremantle and Geraldton 100-200 m. W.A.M.: 1 specimen N7 locality unknown; 5 specimens N2-N5 and N8 dredged by H.M.A.S. *Diamantina*

for C.S.I.R.O. between 100-200 m. off Lancelin Island, Fremantle and Cape Naturaliste. A.M.: J.3055 Endeavour 40-200 m., between Geraldton and Cape Naturaliste.

Nectria ocellata Perrier

Nectria ocellata Perrier (1876), p. 1.

Nectria ocellifera Sladen (1889), p. 319.

There has been much nomenclatural confusion between *N. ocellata* and *N. multispina*. The examination of a good series of specimens from much of the southern coast of Australia has thrown some light on the problem. There are two good species. One is essentially a deep water form having widely separated dorsal tabulae; this is referred to *N. ocellata*. The other is a littoral seastar with close or crowded dorsal tabulae and is referred to *N. multispina*.

Perrier's description of *N. ocellata* (1876) was apparently based upon specimens in the British Museum from Tasmania and Bass Strait. As is discussed later in this paper there is some intergradation between the two species in Tasmanian waters. The specimens examined by Perrier apparently included both intermediates and at least one representative of *N. multispina*. I have seen a photograph of this latter specimen Number 1.8.10 1862 taken by Dr. Mulligan, Tasmania (pers. comm. A. M. Clark). Furthermore, Perrier did not specify a type but it is relatively clear that his description refers primarily to those specimens having widely separated dorsal tabulae. This view is supported by Sladen (1889) and Clark (1914, on p. 140). Sladen's figure is typical of specimens taken along the whole of the southern Australian coast from Bald Island, Western Australia to Norah Head, New South Wales. As the only real differences between the two species relate to the dorsal tabulae the following description is given of *N. ocellata*.

The dorsal tabulae are more or less the same size, circular and well-spaced, so that the distance between them is rarely less than the diameter of a single tabula. The tabulae are usually cylindrical although in some specimens the flaring outwards of the peripheral granules causes them to appear rather hour-glass shaped; they are covered with small hemispherical sub-equal granules which may be well-spaced or comparatively crowded. In the latter case the granules are vaguely polygonal by mutual pressure. The peripheral granules are generally similar in size and character to the internal granules and are usually elevated somewhat so as to form a crown about the

tabula. They may be flared outwards a little, but this may be an artifact of preservation. The dorsal granulation is not developed nearly as much as in *N. ocellifera* or *N. wilsoni.*

Two specimens (J.6775 and E.5398) both from about 100 m. in eastern Bass Strait are notable for the crowding of the dorsal tabulae and the unusually enlarged central granules on the distal tabulae. The specimens from New South Wales (J.7213 and J.7543) taken in Sydney Harbour show the same peculiarities and the granules of their dorsal tabulae are coarse and in some cases bluntly pointed. The spines and pedicellariae orally are also very coarse and thick. Although there is some resemblance in these respects to *N. wilsoni* comparison of the specimens with that species shows that they are much closer to *N. ocellata.* I do not think that the differences shown by these specimens are sufficient to justify specific recognition. Examination of specimens of *N. ocellata* from Bass Strait and from the eastern Australian coast shows that the species is very variable in the characters referred to and that the specimens from Sydney Harbour represent one extreme of the species' range of variation.

These specimens occur near the northern limits of its geographic range and it may be that the morphological variation reflects the genetic instability of peripheral populations.

Figure 1 shows the range of *N. ocellata* from Bald Island in the Great Australian Bight to Norah Head, New South Wales. There is a record of a juvenile specimen (K.654) from Caloundra, Queensland and a specimen (N.M.V.) is reported to have been taken off Mauritius.

Along the South Australian coast and in the Great Australian Bight the species' depth range is from about 30 m. to 200 m. Little is known of its habitat. However the species appears common at 45 m. in Backstairs Passage, South Australia. Here swift tidal currents sweep over the sea floor comprised of rock and coarse shell-grit beds, where large sponge colonies grow prolifically. Numerous specimens were found upon the sponges on which they appear to feed and others were seen moving across the shell-grit beds. On the sea-bed specimens blended with their grey background but at the surface they were seen to be a brilliant orange colour with a few dark red markings scattered irregularly over the dorsal surface. Other specimens have been taken at about the same depth on mud or shell-grit beds between Rapid Head and Cape Jervis, St. Vincent Gulf.

On the Victorian and Tasmanian coasts the seastar invades shallow water as specimens are recorded on jetty piles in Victoria and intertidally in southern Tasmania. It is found there on both rocky and sandy bottoms.

FIG. 1
Map showing distribution of the species of *Nectria* around Australia.

In New South Wales the species has been taken occasionally from deep water. Three specimens were taken in Sydney Harbour on rocky bottom but I am informed by skindivers there that the species is quite rare in shallow water.

Material examined. A.M. (Tas. & Vic.): J.5015, E.5398, J.6775, J.5013, J.5424, E.5362, E.5361, J.5867, J.5424 (3 specimens), J.1202; (N.S.W.), J.7213, J.7543, J.3466; Gt. Aust. Bight (S.A.), J.1614. N.M.V.: 2 specimens Westernport dredged 22.11.1911; 1 specimen Portsea Pier; E.294—(2 spec.) Endeavour. W.A.M.: No. 9676 Bald Is. No. 46 6-62 55-60 m. Gt. Aust. Bight (D. L. Serventy). Q.M.:

G. 4; E.294 off Devonport. H.M.: 2 specimens without label R/r = 64/27 and 59/22 latter intermediate with *multispina*; H99. S.A.M.: (11 specimens). K654 Caloundra, Qld. K585, K596, and K604 from Cape Jervis (collected by the author).

Nectria multispina Clark

Nectria multispina Clark (1928), p. 375.

The existence of this species was probably first noted by Moebius (1859). An examination of the description and figures of *Chaetaster munitus* Moebius 1859 strongly suggests that it is identical with *N. multispina.* Unfortunately the question cannot be conclusively settled as the type specimen in the Kiel Museum was destroyed during World War II (pers. comm. Dr. P. Ohm, Zoologisches Institut und Museum der Universität, Kiel). The locality of the type (Öst Indien) is vague enough to include the whole of the Australian region.

Fisher (1911 p. 163) also appears to have seen a specimen of the species from Westernport, Victoria, but was uncertain as to its specific identity.

It is thought worth while to give a detailed description of the appearance and granulation of the dorsal tabulae to distinguish it from *N. ocellata* with which it has frequently been confused.

The tabulae on the disk and proximally on the ray are elevated, convex and generally lie close together so as to be more or less polygonal through mutual pressure. In some they are so closely packed that papular areas cannot be seen but in other specimens the tabulae are quite rounded and spaced apart. Where the spaces between tabulae exceed one-half of the diameter of a tabulae or thereabouts the specimen is regarded as being intermediate with *N. ocellata.* The granules on the tabulae are polygonal, usually set close together and flattened on top. Some diversity exists in their relative size; for the most part the granules are sub-equal but in some the central 3 to 4 are considerably enlarged. In a few specimens

FIG. 2

Upper Left. Dorsal view of holotype of *Nectria saoria.*

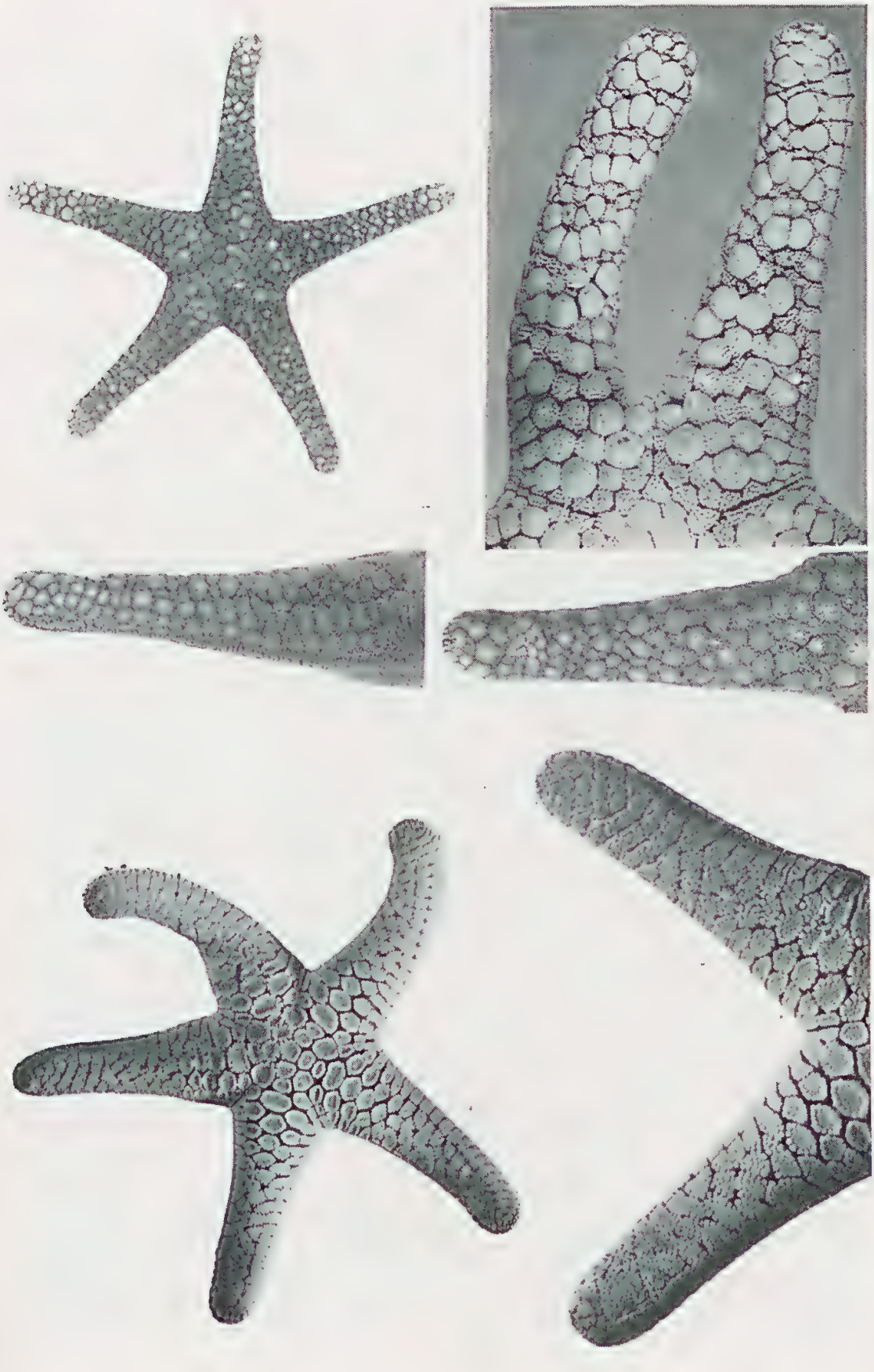
Upper Right. Enlarged dorsal view of portion of paratype of *Nectria saoria* W.A.M. Nod. 8-64 from Hamelin Bay Leeuwin.

Centre Left. Lateral view of ray of holotype of *Nectria saoria.*

Centre Right. Enlarged dorsal view of ray of holotype of *Nectria saoria.*

Lower Left. Dorsal view of specimen Nod. K. 615 of *Nectria macrobrachia* taken at West Island Encounter Bay at 7m. R/r is 34/11mm.

Lower Right. Enlarged dorsal view of rays of specimen Nod. K615 of *Nectria macrobrachial.*



mostly those considered intermediate with *N. ocellata* the granules are not crowded but separated by small gaps from their neighbours so that the granules are not sharply polygonal but rounded at the vertices. The peripheral granules apart from being somewhat smaller are not different in character and shape from the inner granules. Sometimes they form a distinct fringe about the tabula but at other times they are closely appressed to the other granules as in the figure of Mortensen (1925) p. 293 fig. 9b of *N. pedicelligera*. Frequently their ends are truncate thus giving to the granulation a neat, clipped appearance. Other differences of a statistical nature are shown in table 1.

As some differences were observed between the specimens taken in St. Vincent and Spencer Gulfs and those taken from the more exposed coasts of South Australia, the series for each is analysed separately. Gulf populations show very little diversity in morphology but specimens from exposed coasts show considerable variation in the characters set out in table 2 and tend to have larger dorsal tabulae and coarser granules than gulf specimens. The number of specimens intermediate with *N. ocellata* is not great but their examination leaves little doubt that some hybridization occurs on these coasts between *N. multispina* and *N. ocellata*.

Specimens from the Gulfs are invariably a wine red in colour dorsally with some of the prominent tabulae at the base of the arms frequently darker in colour; below the colour is an orange to bright red. Specimens from exposed coasts show much diversity in colour ranging from yellow or orange to a very dark red; their colour below is usually a lighter shade of that dorsally. Specimens from depths exceeding 15 m. are usually found to be lighter in colour than those from shallower water.

The Victorian specimens show the same variability as the South Australian specimens from exposed coasts.

A few of the specimens which I have seen from Tasmania and in particular from D'Entrecasteaux Channel cause difficulty as they show varying degrees of intermediacy between *N. ocellata* and *N. multispina*.

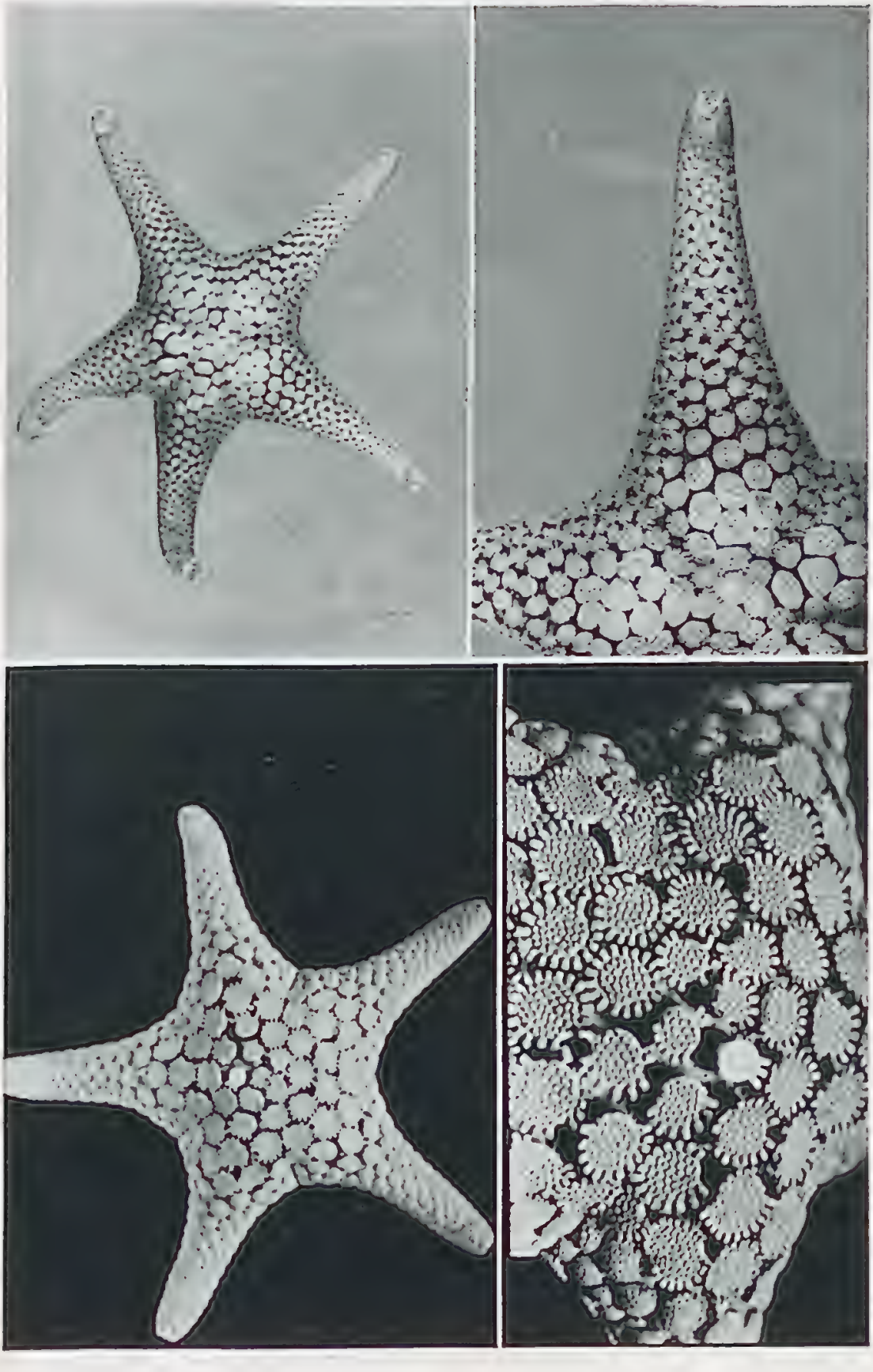
FIG. 3

Upper Left. Dorsal view of specimen of *Nectria multispina* Nod. K.594 taken at Christies Beach, St. Vincent Gulf at 6m. R/r is 71/23mm.

Upper Right. Enlarged dorsal view of same specimen of *Nectria multispina*.

Lower Left. Dorsal view of specimen of *Nectria ocellifera* N7 & R/r is 69/23mm. Photo. Dr. E. P. Hodgkin.

Lower Right. Enlarged view of dorsal disk tabulae of same specimen of *Nectria ocellifera*.



The species is characteristically a shallow water seastar and is found only on rocky substrate. In St. Vincent and Spencer Gulfs it is very common on shallow water reefs on their eastern margins where it ranges bathymetrically from about low water to 15 m. It is most frequently seen in the open amongst the brown algae which characterize such areas. The starfish is usually taken feeding on rock-encrusting organisms but its diet also includes small shellfish and occasionally red algae.

On the exposed coast the seastar's habitat is somewhat different; there is seeks shelter from the force of the swell so that in exposed locations it is found in deeper water between 10 and 30 m. in caves and crevices where it feeds on a variety of encrusting bryozoa, sponges and ascidians. Where there is some protection from the swell it may be found in shallower water between 5 and 15 m. among the red algae upon which it is sometimes found feeding. The species is by no means as prolific on the open coast as in the Gulfs.

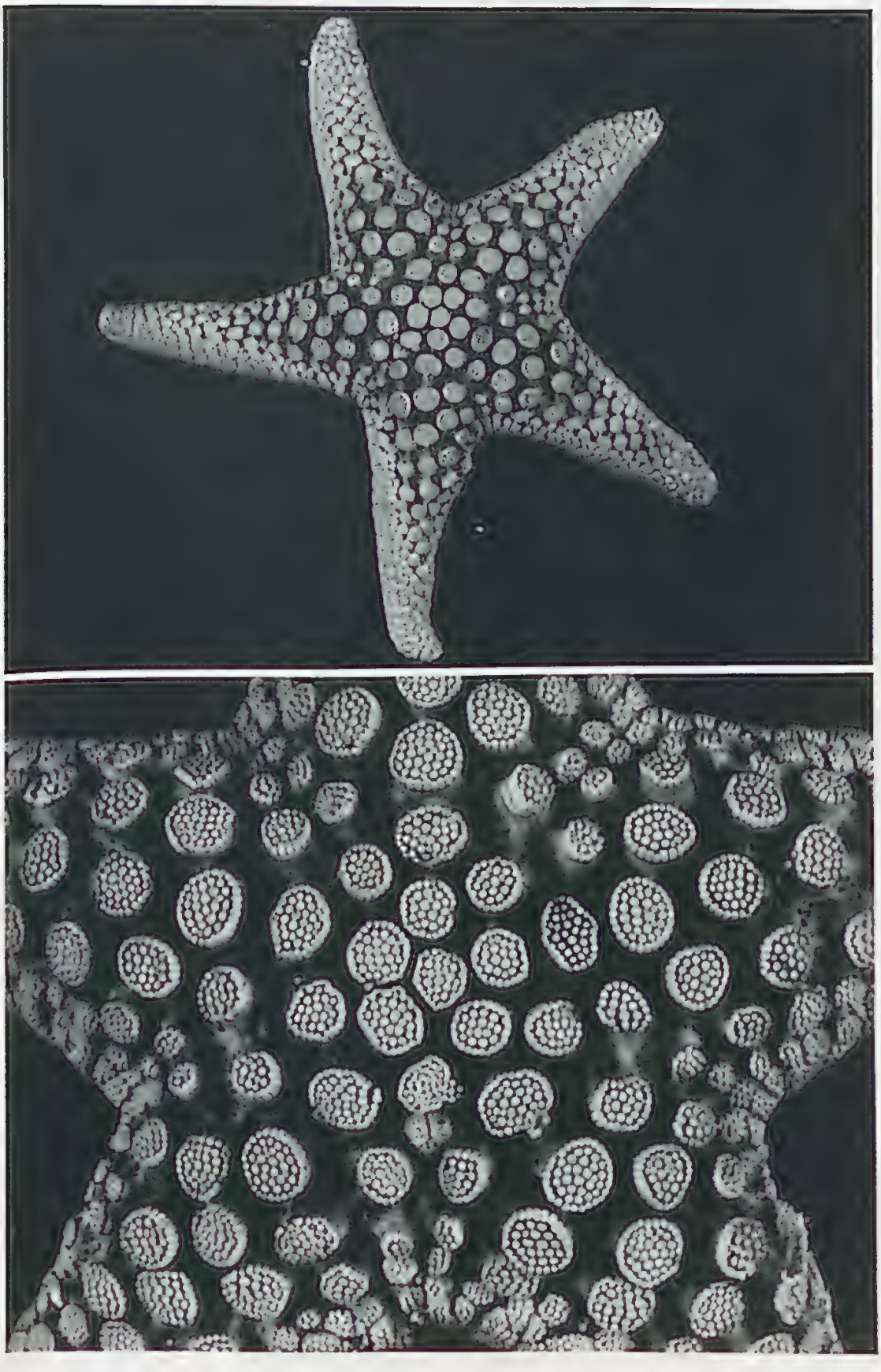
The known range of the species is from Spencer Gulf eastwards and along the Victorian and Tasmanian coasts. It has not been reported from New South Wales waters.

Discussion: The inter-relationships of *N. ocellata* and *N. multispina* are of some interest.

On the South Australian coasts *N. ocellata* is typically an inhabitant of deeper water and appears to be excluded from the Gulfs and the littoral fringe of the southern coast. *Nectria multispina* on the other hand does not occur in deeper water but along the coastal fringe and in the Gulfs. It is considered that the maintenance of the two species is well justified on the existing evidence. If the morphological differences in *N. ocellata* and *N. multispina* were ecologically determined then much more intermediacy would be expected than does in fact occur. Furthermore in the few localities in South Australia where overlap occurs the correlation between phenotype and habitat is not invariable. It is thought that the ecological requirements of the two species are sufficiently different to separate them microgeographically with a probable zone of overlap occurring on the open coast. The greater variability of *N. multispina* and the incidence of specimens intermediate with *N. ocellata* on open coasts suggests that

FIG. 4

Dorsal view of specimen of *Nectria ocellata* from Westernport Victoria taken 22/11/1911 lodged in N.M.V. R/r is 57/22mm. and enlarged view of dorsal disk tabulae of same specimen.



whilst some gene flow takes place between the species in areas of overlap, it is negligible in the gulfs where ecological differences are reinforced by geographical separation.

The concurrence of both species on Victorian and Tasmanian coasts in similar habitats in shallow water and the degree of intergradation observed there suggests a similar reduction of isolating mechanisms between the species with some consequential interbreeding.

Material examined. A.M.: J.6752, J.6776, J.4553. N.M.V.: 3 specimens Cape Paterson Vic.; 1 specimen Torquay, Coll. D. Watson; 1 specimen Flat Rocks Inverloch 27.1.64; 1 specimen Waratah Bay, Coll. J. H. McPherson 1951. Q.M.: G.2225 St. Vincent Gulf. H.M.: H.96, H.97. S.A.M. (82 specimens): K19, K589, K590, K592-595, K624, K655, K662-667, K669. (Collected by the author.)

Nectria wilsoni Shepherd and Hodgkin

Nectria wilsoni Shepherd and Hodgkin 1966, p. 119.

I have seen nine more specimens of this species, one numbered K.51 (S.A.M.) taken at Bunbury, Western Australia and eight numbered 1-66 (W.A.M.) taken at Two People Bay, Western Australia. Some of the specimens are juveniles the smallest having R/r = 37/12 mm. but all of them are within the range of variability of the species. The known distribution of the species as now extended is from Beagle Island (29° 50′ South Latitude) on the Western Australian coast to Two People Bay in the Great Australian Bight.

Nectria macrobrachia Clark

Nectria macrobrachia Clark (1923), p. 236.

The species shows little variation throughout its range. In all specimens the arms are relatively long, the tabulae are low and always excessively crowded together and usually appear rather concave in their general facies. The inner granules are invariably irregular, polygonal, closely packed, very low, and usually subequal, in size. The peripheral granules are distinctly larger than the inner granules, and are elevated and set closely together so as to form a crown around the tabula.

The two specimens taken off Port Gregory, Western Australia are notable as they are atypical in the shape of the peripheral granules which are flared and radiate outwards and are quite different in character from the inner granules. These show marked affinities with *N. ocellifera.*

Pedicellariae are generally absent; only on one specimen (from Dunsborough, Western Australia) were any detected. In that case it was three-pronged, thick at base, stumpy and rounded at the top and situate orally behind the mouth plate. On many specimens a number of adjacent oral spines are polygonal and present a flat face to each other; these appear to be capable of performing the function of pedicellariae. The colour is a particularly constant feature; nor is it fugacious as in the other species. It ranges from a light yellow or fawn to a brown-orange or even pink colour and all specimens except some from Western Australia show the very ends of the rays prettily tipped with a darker brown. The South Australian specimens are lighter in colour than those from Western Australia. Frequently the peripheral granules of the dorsal tabulae are paler in colour than the inner granules.

Like other members of the genus this species is an inhabitant of rocky substrate and feeds similarly upon bryozoan polyps, sponges and other encrusting organisms. Bathymetrically it ranges from the intertidal zone down to about 350 m. Along the South Australian coast it is abundant on the shallow limestone and granite reefs of southern Yorke and Fleurieu Peninsulas on exposed coasts. It is equally at home at depths of 50 m. in Backstairs Passage living on sponge colonies. The species has not been recorded from the calmer waters of the two gulfs.

Material examined. W.A.M.: 1 specimen Hall Bank Fremantle 1.2.63 R/r 54/15, B.R.W.; 1 specimen Dunsborough on rock 20 m. 15.4.63, B.R.W.; 1 specimen Rottnest 26 m. Duffield Ridge 18.4.59; 2 specimens Pt. Gregory 120 m. Stn. DM/1/40/64, C.S.I.R.O.; 1 specimen Dunsborough Limestone reef 55′ 15.4.63; 1 specimen Dunsborough 3 miles offshore limestone 25/2/63; 1 specimen Dunsborough 18.4.60 4 miles offshore B.R.W. rocky bottom Geographe Bay at 18 m. S.A.M.: K586 (1 specimen) Cape Jervis at 36 m.; K615 (3 specimens) West Island at 10 m.; K660 (11 specimens) Pondelowie Bay, Yorke Peninsula at 5 m. (all collected by the author). N.M.V.: 1 specimen Cape Schank 8/6/61.

Nectria saoria n. sp.

Diagnosis: Disk small, arms long and tapering. Plates on aboral surface of disk form low paxilliform tabulae very crowded and covered with small polygonal granules. Distally aboral arm tabulae low and crowded very variable in size but similar in shape and appearance to other aboral tabulae. Papulae are common on the distal part of the arm and occur intermarginally.

Superficially the species resembles *N. multispina* but differs from it and other members of the genus in the extreme crowding of the aboral tabulae, which are invariably polygonal through mutual pressure, and in the similarity in structure and appearance between the distal tabulae of the rays and those of the disk. The other species (apart from *N. macrobrachia*) show quite marked differences between the disk and distal arm tabulae, and there are few or no papulae distally or intermarginally.

Description of holotype: Rays 5. R/r is 56/14 mm. R = 4r. Br is 18 mm. at base, 11 mm. at the middle and 8 mm. near the tip of the ray. Disk relatively small, a little elevated; rays narrow, rounded somewhat raised proximally and terete for distal half. Aboral plates form convex tabulae of rather smooth appearance, more or less irregularly polygonal, those on the disk near base of arms being larger (3-4 mm. across) and those distally 2-3 mm. across.

Tabulae very crowded and covered by coat of low slightly convex, closely appressed polygonal granules. On a plate 4 mm. across there are 20-30 inner granules among which there may be considerable disparity in size, the centre ones sometimes twice as large being up to 1 mm. across. Peripherally, there are from 30-40 distinctly smaller granules about 0.2 mm. across and sometimes flared a little to form a fringe and often giving a "furry" appearance to the dorsal surface. Plates on distal part of ray covered by similar if slightly smaller granules.

Papulae emerge between the aboral tabulae in groups of from 5-15. They are more frequent on disk and proximally on ray than distally on ray, and are present between marginal plates.

Madreporite small and inconspicuous, about 2 mm. across midway between centrum and margin.

Marginal plates distinct proximally but distally become crowded and difficult to distinguish from surrounding plates; about 24-26 in each series, proximally twice as high as long; midway along ray squarish and flat; distally smaller convex and irregular. All are covered with a uniform coat of small polygonal granules which tend to be individually distinct and rounded.

Actino-lateral areas small, plates crowded with low coarse prismatic granules close enough to obscure the outlines of individual plates.

Adambulacral plates about 45, each with three furrow spines, rarely two, subequal prismatic and blunt. Proximally furrow spines 3 mm. long and 0.3 mm. across. On the surface of each plate five or

six thick short and prismatic sub-ambulacral spines; the three longest of these adjoin the furrow spines and the remaining two or three behind resembling the prismatic granules on the first series of actino-laterals.

Some pedicellariae on aboral tabulae nestling under marginal granules and comprising three to four slightly curved flattened spines. There are none orally.

Oral plates with six or seven thick prismatic spines, the innermost stoutest; on surface of each plate there are eight shorter and stouter spines and distally a group of 2-4 short, thick, granuliform spines.

Material examined. The holotype (K670) was taken at 10 m. on a submerged limestone reef between Wright Is. and The Bluff, Encounter Bay. Twelve specimens are designated paratypes but show no significant differences from the type. Four of them (K628) are from the same reef, 4 specimens (K627) from West Island, Encounter Bay, 2 specimens off Wright Island Encounter Bay and one (K658) taken between Thistle and Hopkins Islands,, Spencer Gulf on a limestone reef at 6 m. All specimens were taken by the author whilst diving. The other paratype (No. 8-64) from Hamelin Bay, Leeuwin, is lodged in the Western Australian Museum.

The specimens were all a bright rose-red colour in life. The skin of the papular areas aborally was black and the papulae protruded between the tabulae, so that the tabulae appeared to be outlined prettily in black. The colouration is constant and quite different from any other species of the genus. In preserved specimens the papular areas are concealed under the aboral tabulae.

The habitat of the species is restricted to rocky reefs on exposed coasts where it is found down to about 20 m. It feeds on rock-encrusting organisms particularly colonial ascidians on which a slight groove may be seen where it has grazed the surface. It also feeds on lithothamnia and other red algae; I have observed specimens engulf fronds of the delicate red alga *Neomonospora griffithsioides* Harvey leaving behind only the colourless cellular structure.

There is no doubt as to the generic location of the species; in dimensions, shape and habitat it is very similar to *N. macrobrachia* whereas the granulation of the dorsal tabulae resembles that of *N. multispina.*

There are seven specimens in the Western Australian Museum which are referred to this species.

W.A.M. 6-64 R = 67 mm. 60′ near Pilot Rock Yallingup.

W.A.M. 7-64 R = 67.5 mm. near Pilot Rock Yallingup.

W.A.M. 8-64 R = 59 mm. Hamelin Bay, Leeuwin. Jetty Piles.

W.A.M. 4-62 R = 57 mm. North side of North Twin Peak Is. Recherche Archipelago. Intertidal granite. Colour pinkish-red.

W.A.M. 5-64 R = 45 mm. 16 m. 3 miles off Dunsborough, Geographe Bay.

W.A.M. 5-62 R = 18 mm. 1 mile east of Frenchman's Bay, Albany intertidal pool.

Dr. E. P. Hodgkin has also two specimens from Cheyne Beach near Albany taken inter-tidally and one specimen from Shoreham near Melbourne, Victoria.

From the material before me the species has a distribution from South Western Australia to Port Phillip Bay, Victoria.

Nectria pedicelligera Mortensen

Nectria pedicelligera Mortensen (1925), p. 291.

I have not seen any specimens of this species. However the description of the type and the figures shown do not disclose any real difference from *N. multispina*. The pedicellariae shown by Mortensen are not an uncommon feature in the genus. The species must be retained awaiting examination of specimens.

REMARKS ON THE VALUE OF CERTAIN CHARACTERS

The results of morphological data obtained from each specimen are summarized in table 1.

R/r Ratio. The differences between species may be statistically significant. In three species (*N. saoria, N. macrobrachia* and *N. ocellifera*) the relative size of disk and arms is constant and a reliable character but is extremely variable in the other species.

Dorsal tabulae. The granular covering of the tabulae on the disk and at the base of the rays is of value diagnostically. The shape and appearance of the granules is a constant feature for any species, although the size of the granules on a tabulae shows some variation even for a single specimen. For this reason only the observed range in the number of granules on the prominent dorsal tabulae at the base

of the ray is given. In those species where the number of granules is relatively few the grains are usually large hemispherical and well-spaced.

The granular covering of the plates distally on the rays is also of significance. In two species (*N. saoria* and *N. macrobrachia*) they are very similar to the proximal tabulae but in the other species they are low and covered by a uniform coating of small grains so that it is difficult to distinguish individual tabulae.

Papulae. The presence of numerous papulae emerging between the distal plates of *N. saoria* and *N. macrobrachia* is a useful diagnostic character. In the other species papulae are rare or wanting beyond the proximal half of the ray.

Oral spines. Certain statistical differences are noted in the number of furrow spines and the spines on the mouth plates. Sometimes the number of spines on a plate vary between arms, and in such cases that number is adopted which is predominant in the specimen for the purposes of the table.

Pedicellariae. Apart from the two species where they are rare or absent the occurrence or type of pedicellariae has little significance. They may be entirely absent or may occur dorsally beneath the tabulae or on the oral side or both. They usually comprise from three to six fine spines bent inwards at the tip but sometimes there are two to three short thick bluntly pointed component spines. Where present dorsally they are to be found on the tabular shaft (as in Mortensen's fig. 9a (1925) p. 293) and orally either on the mouth plate or in the series behind the furrow spines. Occasionally they are seen in the oral intermediate areas.

Marginal Plates. The number of marginal plates depends largely upon the length of the ray. *N. ocellifera* having shorter rays has considerably fewer plates than the other species. The character is of little use.

KEY TO THE SPECIES OF *NECTRIA*

1. Disk small, rays long and tapering R/r is 3 to 4. Disk tabulae low and crowded—dorsal tabulae distally on rays similar in form and granulation to those proximally. Papulae emerge between tabulae throughout length of ray 2

   Disk larger. Disk tabulae conspicuously elevated. Tabulae distally on ray low and crowded with different type of granulation usually a cluster of small grains. Papulae rare or wanting distally on ray 3

2. Dorsal tabulae crowded, with low closely packed polygonal granules, the peripherals larger and provide a raised margin so that each tabula appears concave. Colour: Pale yellow to orange, the tips of rays darker. Papular areas cannot be seen . . . . . *macrobrachia*

   Dorsal tabulae convex with covering of tightly packed polygonal granules, the peripherals smallest. Colour bright red, papular areas black . . . . . *saoria*

3. Granules of dorsal tabulae very low (elevated about 0.1 mm.) irregular and flat. Peripheral granules are large and scale-like and form a regular radiating marginal fringe . . . . . *ocellifera*

   Granules of dorsal tabulae not low, but hemispherical or polygonal, 0.5 to 1 mm. high 4

4. Distal tabulae with a large dominant central hemispherical granule, surrounded by a ring of smaller grains. Disk tabulae with large protuberant well-spaced dome-shaped granules . . *wilsoni*

   Distal tabulae comprised of group of small crowded grains, sub-equal in size 5

5. Dorsal tabulae elevated, well-spaced, with covering of hemispherical granules, the peripherals forming a radiating fringe . . . . . *ocellata*

   Dorsal tabulae elevated and crowded and covered with closely packed polygonal flat-topped granules . . . . . *multispina*

TABLE 1

Morphological characteristics of species of the genus *Nectria*

	ocellifera	*ocellata*	*multispina*	*wilsoni*	*saoria*	*macrobrachia*
Number of specimens examined ...	9	23	82	17	21	24
Maximum R observed (in mm.)	61	121	98	110	76	62
R/r—						
Range	2.5–3.0	2.1–3.5	2.7–3.7	2.6–3.5	3.0–4.0	3.2–4.0
Mean ± 1 S.D.	2.7 ± 0.22	2.8 ± 0.41	3.2 ± 0.23	3.1 ± 0.30	3.5 ± 0.19	3.6 ± 0.22
Range in number of granules on large tabulae midradially at base of ray	50–75	35–70	50–105	20–80	35–75	60–160
Furrow spines..	3 4 62% 38%	3 4 5 62% 33% 5%	3 4 5 84% 14% 2%	2 3 12% 88%	2 3 4 26% 70% 4%	2 3 16% 84%
Spines on each proximal margin of mouth plate	5 6 7 17% 50% 33%	6 7 8 9 26% 22% 39% 13%	6 7 8 9 22% 53% 22% 3%	5 6 7 7% 55% 38%	5 6 7 37% 53% 10%	4 5 6 7 10% 67% 20% 3%
Pedicellariae...	Absent	Present	Present	Present	Present	Absent
Supero-marginal plates	15–22	25–30	20–30	20–28	22–28	20–25

TABLE 2

Morphological differences between specimens of *N. multispina* taken in St. Vincent and Spencer Gulfs and on exposed coasts.

	Gulf Specimens	Exposed Coast Specimens
Specimens examined	43	39
R/r—		
Range	2.8–3.3	2.8–3.8
Mean R/r ± 1 S.D.	3.1 ± 0.14	3.3 ± 0.28
Oral spines on each side of mouth plate	6 7 8 15% 65% 20%	6 7 8 9 31% 47% 19% 3%
Furrow spines	3 4 92% 8%	3 4 5 73% 23% 4%

ACKNOWLEDGMENTS

I am grateful to the officers of the Museums of each State in making the respective collections available. Dr. E. P. Hodgkin and Miss E. Pope read the manuscript and have given valued criticism.

REFERENCES

Clark, H. L., 1914: Rec. W.A. Mus., pp. 139-140.

———— 1916: Endeavour Scientific Results, Vol. IV, 34-35.

———— 1923: Journ. Linn. Soc. Lond., 35: 236-237.

———— 1928: Rec. S.A. Mus., 3: 375.

———— 1946: Echinoderms of Australia, p. 85-86.

Dujardin, M. F. and Hupé, M. H., 1862: Suites à Buffon, Echinodermes, p. 406.

Fisher, W. K., 1911: Bull. U.S. Nat. Mus. No. 76, pp. 163, 164.

Gray, J. E., 1842: Ann. Mag. Nat. Hist., vi: 287.

Moebius, K., 1859: Neue See Sterne des Hamburger und Kieler Museums, p. 3. (Abhandl. a.d. Gebiete Naturw. hrsg. v.d. naturwiss Bd V abth. 2.)

Lamarck, J. B. P., 1816: Anim. s. vert., ii: 553.

Mortensen, Th., 1925: Vidensk Medd., 79, 291-4.

Muller, J. and Troschel, F. H., 1842: System der Asteriden, p. 60.

Peron, F., 1812: Voyage of Discovery to Australia, 1: 56, 83.

Perrier, E., 1876: Arch. Zool. Exper., V: 1-6.

Shepherd, S. A. and Hodgkin, E. P., 1966: Journ. Roy. Soc. W.A., Vol. 48, 4, pp. 119-121.

Sladen, W. P., 1889: Challenger Rep. Asteroids, pp. 319-320.

NOTE.—Unfortunately I was not able to see Miss A. M. Clark's paper on the Echinoderms of the Port Phillip Survey (Mem. Nat. Mus. Viet., No. 27, p. 298) before this paper went to press. As some confusion between the species is evident in her work I add the following comments upon table 3 at p. 315.

The first thirteen specimens are probably *N. ocellata* although two of them (90.5.7443 and 62.7.952) may be intermediate with *N. multispina*. The next three specimens W.A.M. 18.59; 19.59; and 2.62) are *N. wilsoni* (one of them is figured in pl. 1). The next four specimens are all well within the range of variation of *N. multispina* and must be referred to that species (except the type of *N. pedicelligera* upon which judgment is reserved). I base this conclusion upon the data supplied and the figures of two of the specimens which are in print.

Of the last group of specimens, five (W.A.M. 5.62; 4.62; and 1.62 and the two specimens of Dr. Hodgkin from Rottnest Island), are *N. saoria* and the remainder are *N. multispina*.

THE DISTRIBUTION OF INTRODUCED SNAILS IN SOUTH AUSTRALIA

By D. E. POMEROY and HELENE M. LAWS

INTRODUCTION

With the development of gardens and agriculture in South Australia has come the introduction of a variety of exotic terrestrial snails; some have settled unobtrusively and are seldom noticed, some have probably escaped notice completely and are yet to be found, but others have made themselves felt by their depredations in gardens and crops or by their countless numbers. Record has been made of species in South Australia on a number of different occasions (Verco, 1922, 1924; Cotton, 1954; Quick, 1952, 1953; Taylor, 1928) but no account has been given of their distribution in the State. In the following pages the introduced species and their present distribution will be considered.

SNAILS INTRODUCED INTO SOUTH AUSTRALIA

During the past hundred years, ten species of exotic snail are known to have become established in South Australia (table 1). Six of these do occur naturally in the British Isles but the ranges of all ten include the Mediterranean region. All species (except *Ferussacia*) are known (Pomeroy, 1966; Laws, unpublished) to have the ability to survive in a dormant state for several months, an ideal attribute for long range dispersal by man.

Times of arrival and establishment in South Australia are extremely difficult to ascertain. The earliest known records for these species in South Australia are given in table 2 but it is very likely that some, especially the smaller inconspicuous ones, were established for a considerable time before they were noted. The earliest recorded introduction is that of *Helix aspersa* which was brought to Adelaide before 1879 and liberated in the West Terrace cemetery in the hope that it would help in eradicating introduced slugs; it was also thought to have been brought in by Sir Samuel Way to provide food for aviary birds (Cotton, 1949). The British Isles would be the most likely place of origin of these importations. *Cochlicella ventrosa, Helicella stolismena* and *Ferussacia* (Section *Ferussacia*) occur naturally only in the Mediterranean region (including Spain and Southern France) and most probably came from that area. *H. neglecta* the second earliest recorded species, must have come from the Mediterranean region since the establishment of a colony in Kent in 1915 post-dates its introduction to South Australia. *Theba* occurs in the British Isles,

TABLE 1

Snails introduced into South Australia, their native range and other areas of introduction

Species	Native Distribution	Areas of Introduction	
		World	Australia
Ferussacia sp. (Section *Ferussacia*)	Mediterranean	—	—
Oxychilus alliarius (Miller)	British Isles, Europe, North Africa, Scandinavia	South Africa, U.S.A...	N.S.W.
Helicella virgata (da Costa)	British Isles, West Europe, Mediterranean	—	Victoria, Queensland
H. neglecta (Draparnaud)	South France, Mediterranean	British Isles (in Kent, 1915)	—
H. caperata (Montagu)..	British Isles, Europe, East Mediterranean	—	Victoria, Tasmania
H. stolismena (Bourguinat)	Spain, South France..	—	—
Helix aspersa (Müller) ..	British Isles, Europe, West Mediterranean to Black Sea	U.S.A., South Africa, New Zealand, Mexico, Chile, Argentina, Haiti	Victoria, Tasmania, Queensland, West Australia, New South Wales
Cochlicella acuta (Müller)	West and South West British Isles, South West Europe, Mediterranean	—	West Australia
C. ventrosa (Ferussac) .	South France, Mediterranean	U.S.A., South Africa .	Victoria, Tasmania
Theba pisana (Müller) ..	Spain, West France, Mediterranean, Local only in South West British Isles	California (now eradicated), Somaliland, South Africa	West Australia, Victoria

TABLE 2

Earliest authentic records of introduced species in South Australia

Species	Date	Locality	Reference
Ferussacia sp.	1953	Linden Park, Adelaide	Cotton, 1954
Oxychilus alliarius	(1935)	(Hove).....	S.A.M. Coll.
	1962	Linden Park.....	S.A.M. Coll.
Helicella virgata	1920-21	Millicent	Verco, 1924 (as *Helix pisana*)
H. neglecta	1891	Levens, Yorke Peninsula	Cox, in Taylor
H. caperata	1934	Robe	S.A.M. Coll.
H. stolismena.....	1912	Robe	S.A.M. Coll.
Helix aspersa.....	Before 1879	Adelaide	Cotton, 1949
Cochlicella acuta	1953	Minlaton, Yorke Peninsula	S.A.M. Coll.
C. ventrosa	1921	Mount Gambier	S.A.M. Coll.
Theba pisana	1928	Port Adelaide	Taylor, 1928

but locally and in the extreme South West and therefore most probably also came from the Mediterranean (Quick, 1953). Quick is of the opinion that *H. virgata* is also an introduction from that region since some specimens which he examined are much closer to Mediterranean forms than to British ones. There is thus evidence of Mediterranean origin for at least half of our introduced land snails. Similarities of climate would certainly favour the establishment of Mediterranean species in South Australia.

The most recent introductions are those of *Cochlicella acuta* and *Ferussacia* sp. *Oxychilus alliarius* also appeared in the Linden Park area in 1962 (Laws, in press); a small collection of three similar shells was made at Hove in 1935 but they cannot positively be assigned to this species.

THE DISTRIBUTION OF THE INTRODUCED SNAILS

The distribution of introduced land snails in South Australia is shown in fig. 1. Centres of establishment are on Yorke Peninsula, in the Adelaide area, and in the South-East of the State where, in each case, six species occur.

Helix aspersa, Helicella virgata and *Cochlicella ventrosa* occur widely throughout the agricultural regions of the State, although *H. aspersa* is confined to areas with summer watering. Apart from the localities of the earliest records, there is little information on the spread of *H. virgata* and *C. ventrosa* except that both have become established on Kangaroo Island within the last 15 years (H. M. Cooper, pers. comm.). *Helix aspersa* arrived there considerably earlier, but it has only recently been found on southern Yorke Peninsula probably having been introduced to Edithburgh within the past two years (M. Kenny, pers. comm.). *Helicella caperata* is restricted to the South-East and is also abundant in Victoria; *H. stolismena,* originally recorded from Robe in 1912, is now known to occur at Murray Bridge where it is locally abundant in an abandoned quarry along with *H. virgata, C. ventrosa* and the native snails *Elsothera murrayana* (Pfeiffer) and *Paralaoma stabilis* Iredale.

**Oxychilus alliarius* and *Ferussacia* sp. are both recorded only from the Adelaide area. *Helicella neglecta* and *Cochlicella acuta* are restricted to Yorke Peninsula; a single collection of *H. neglecta* in the South Australian Museum does bear the locality label "Naracoorte" but this has not been confirmed.

* *Oxychilus alliarius* has recently, June 1967, been found at Mount Gambier, after this paper had been set up and the figure on p. 486 reproduced. It has not been possible therefore to include this occurrence on this map.

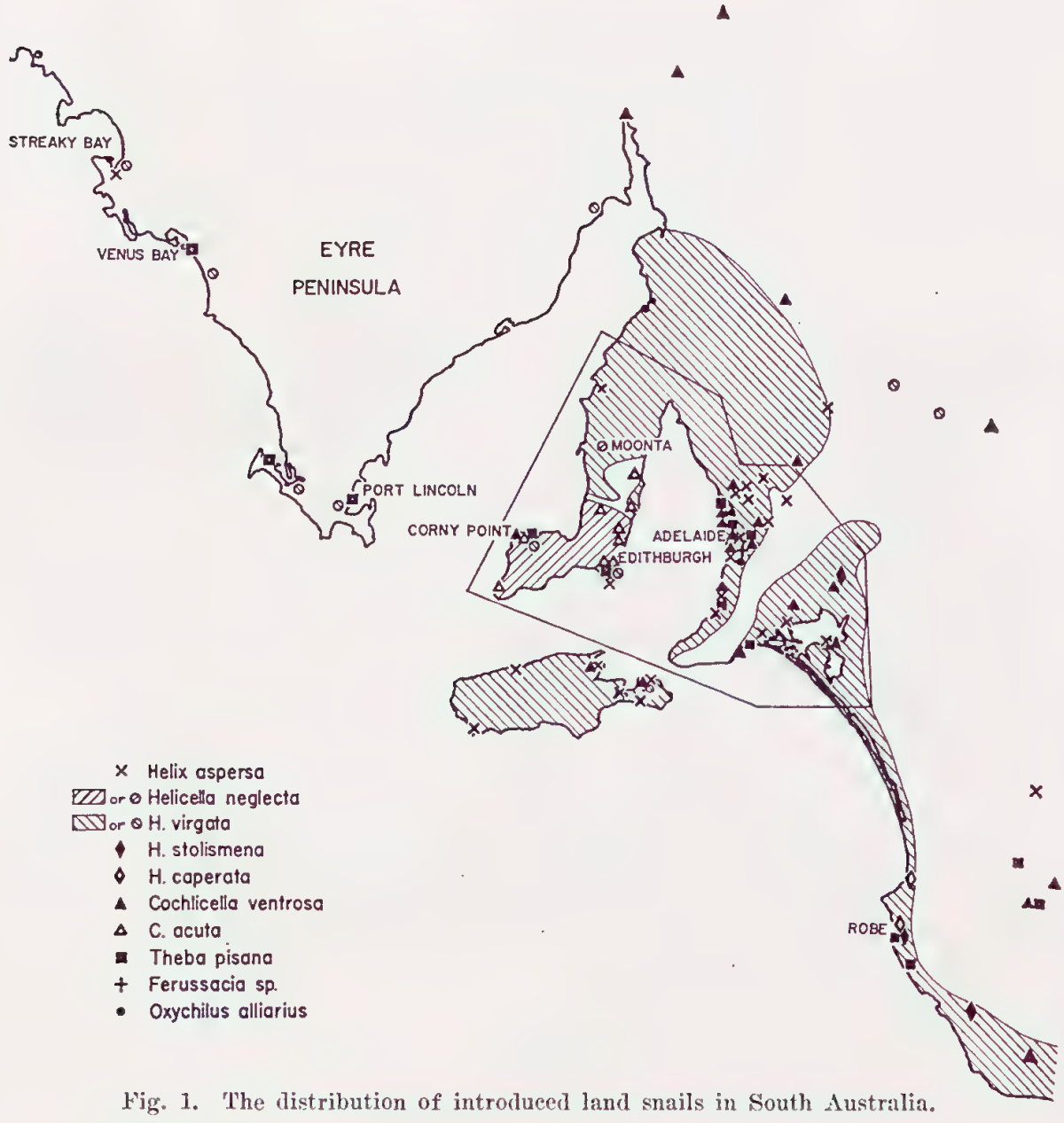


Fig. 1. The distribution of introduced land snails in South Australia.

It is likely that *Theba pisana* has reached its present distribution relatively rapidly over the past few years. Taylor (1928) recorded it from Outer Harbour, where it is at present plentiful, but the earliest South Australian collection of this species in the South Australian Museum is from Port Lincoln in 1956. All other distribution sites shown on fig. 1 have been established by the authors since 1962.

THE DISTRIBUTION OF *HELICELLA VIRGATA* AND *H. NEGLECTA*

Of the ten introduced species, *Helicella virgata* is the most widespread, its range in the State extending from Ceduna to the Victorian border. The main concentration is on the Adelaide Plains,

adjacent areas of northern Yorke Peninsula, and the Lower Murray Valley. *H. neglecta* occurs on southern Yorke Peninsula. During summer these two species are easily observed on fence posts, telegraph poles, grass and shrubbery where they spend the dry months in a dormant state; in winter they are much less conspicuous. Because of this their distribution was studied during the summer.

Method of Survey.

Roadsides provide a favourable habitat for *Helicella* and also an easily accessible habitat where a large number of observations could be made in a relatively short time. The method used was as follows: a series of roads and tracks, parallel to each other and each about 5 miles from the next, was plotted on large-scale maps. Stops were made at 5-mile intervals along these routes and the abundance of snails estimated at each; about 600 sites were examined in this way. If no snails were found at a stopping-point, a continual watch was kept until they were found again to enable distribution boundaries to be established as accurately as possible.

Map of Distribution.

The survey included all the known range of *H. neglecta* and the main areas where *H. virgata* occurs. The results are shown in fig. 2, the extent of the survey and the overall distribution of *H. virgata* being given in fig. 1, along with distribution of other species. The remainder of the range of *H. virgata* was covered in much less detail by a series of transects along approximately 2,500 miles of main roads. This information, together with records from the Museum Collections, was used to determine the full extent of the distribution of *H. virgata* (fig. 1).

Figure 2 shows the relative densities of *H. virgata* and *neglecta* in different parts of their ranges. Five distribution ratings were used as follows:—

Rating 0: no snails found.

Rating 1: snails found at less than a quarter of the sampling-points.

Rating 2: areas where snails were found at between a quarter and a half of the sampling-points.

Rating 3: snails found at more than half of the sampling-points.

Rating 4: snails found at every sampling-point, and at a density of at least 20/m^2 on both sides of the road at each sampling-point.

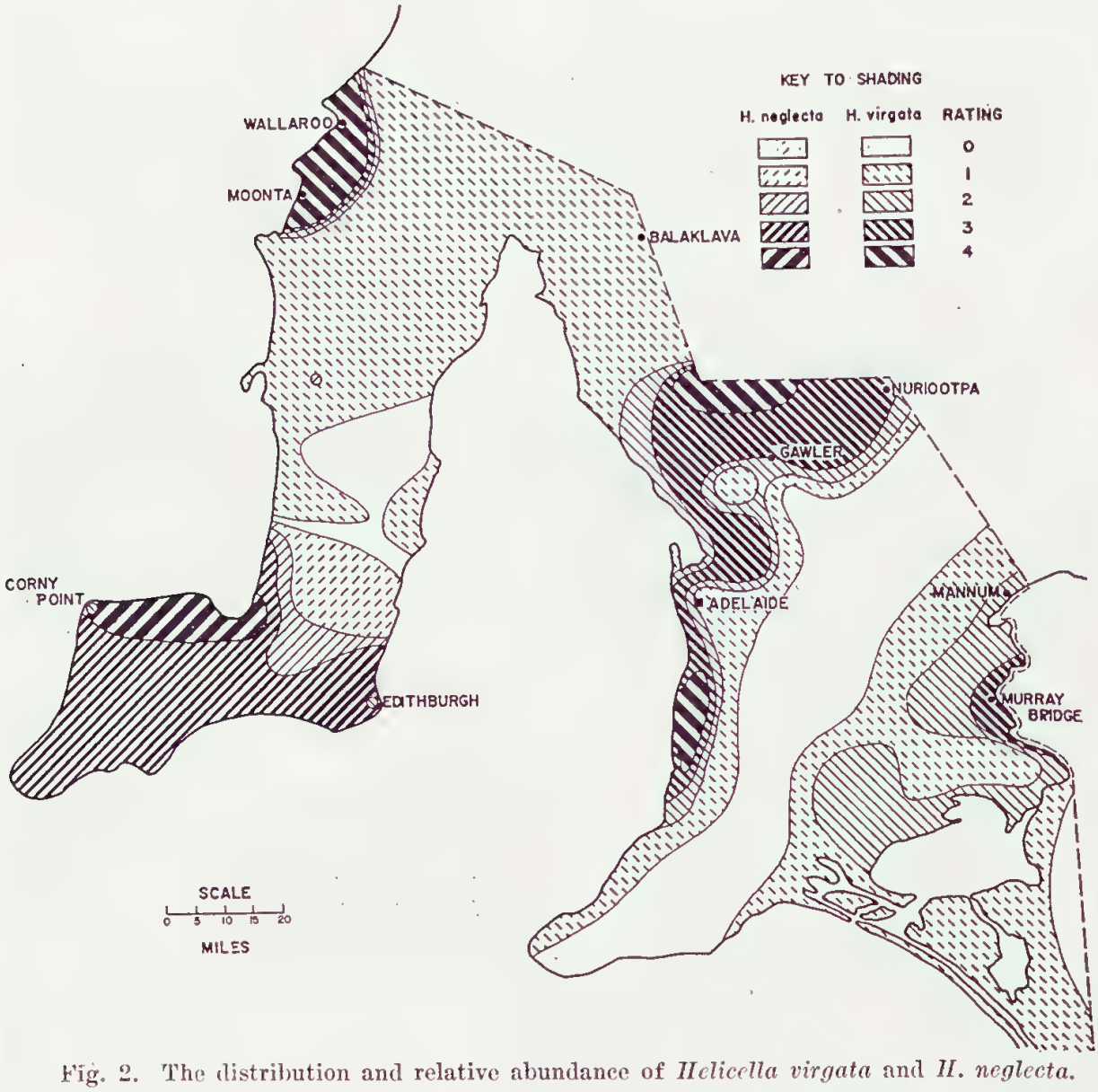


Fig. 2. The distribution and relative abundance of *Helicella virgata* and *H. neglecta*.

Since sampling-points were effectively random, fig. 2 indicates the probabilities of finding snails at any randomly selected roadside site within the area shown. The survey was, however, made in the summers of 1963-64 and 1964-65. Some changes in distribution will certainly occur from year to year and observations of marked yearly fluctuations have been made at a single site.

With the exception of three small colonies on Yorke Peninsula, the ranges of the two species do not overlap; they do, however, show a remarkable confrontation (fig. 2). It is also clear from the figure that *H. virgata* is relatively uncommon over most of its range.

The Spread of "H. virgata".

Although there is some evidence as to the time of arrival of this species in South Australia, there is almost no record of its spread from

then to the present. There is, however, evidence that it is still spreading. On Eyre Peninsula its distribution is confined to coastal townships which are old ports. This, as well as a marked tendency to occur along major roads more frequently than minor ones, suggests a correlation with man's activities.

The most striking correspondence between the activities of man and the distribution of *H. virgata* is seen in the Mid-North of the State. Figure 3 shows the results of a survey in that region. Most snails are found near townships. In the northern part of the area no snails were found and this part may be unsuitable for them. In the southern parts of the area, snail distribution tends to join one township to the next. In the central part there are no occurrences of snails more than three or four miles from a township. Of the 37 townships shown in fig. 3, 19 are served by both a main road and a railway, six by a main road only, six by a railway only and six by neither. The presence or absence of snails at these townships is shown in table 3. The presence of a main road or railway seems to increase the likelihood of *H. virgata* becoming established. The null hypothesis that neither a main road nor a railway increases the probability of snails being present at a township can be tested. A 2X2 contingency test gives a value of $Chi_1^2 = 4.82$, after applying Yates' correction. The probability of this value arising by chance is about 0.03 and the null hypothesis may therefore be rejected.

TABLE 3

The relationship between transport routes and the presence of *Helicella virgata* in townships of the mid-north of South Australia

Transport Routes Serving Townships	Number of Townships	
	Snails Present	Snails Absent
Main road only	4	2
Railway only	3	3
Railway and main road	16	3
Neither railway nor main road	1	5

It is thus most likely that *H. virgata* has spread and is spreading by man's activities, in the Mid-North. Snails may reach outlying townships on vehicles and railway wagons which they have previously climbed during a dry spell. Rain will bring them down from their means of transport to become established as a new colony if conditions are favourable. Townships such as Burra, Spalding and Port Broughton are at this stage. Such a township then becomes a centre

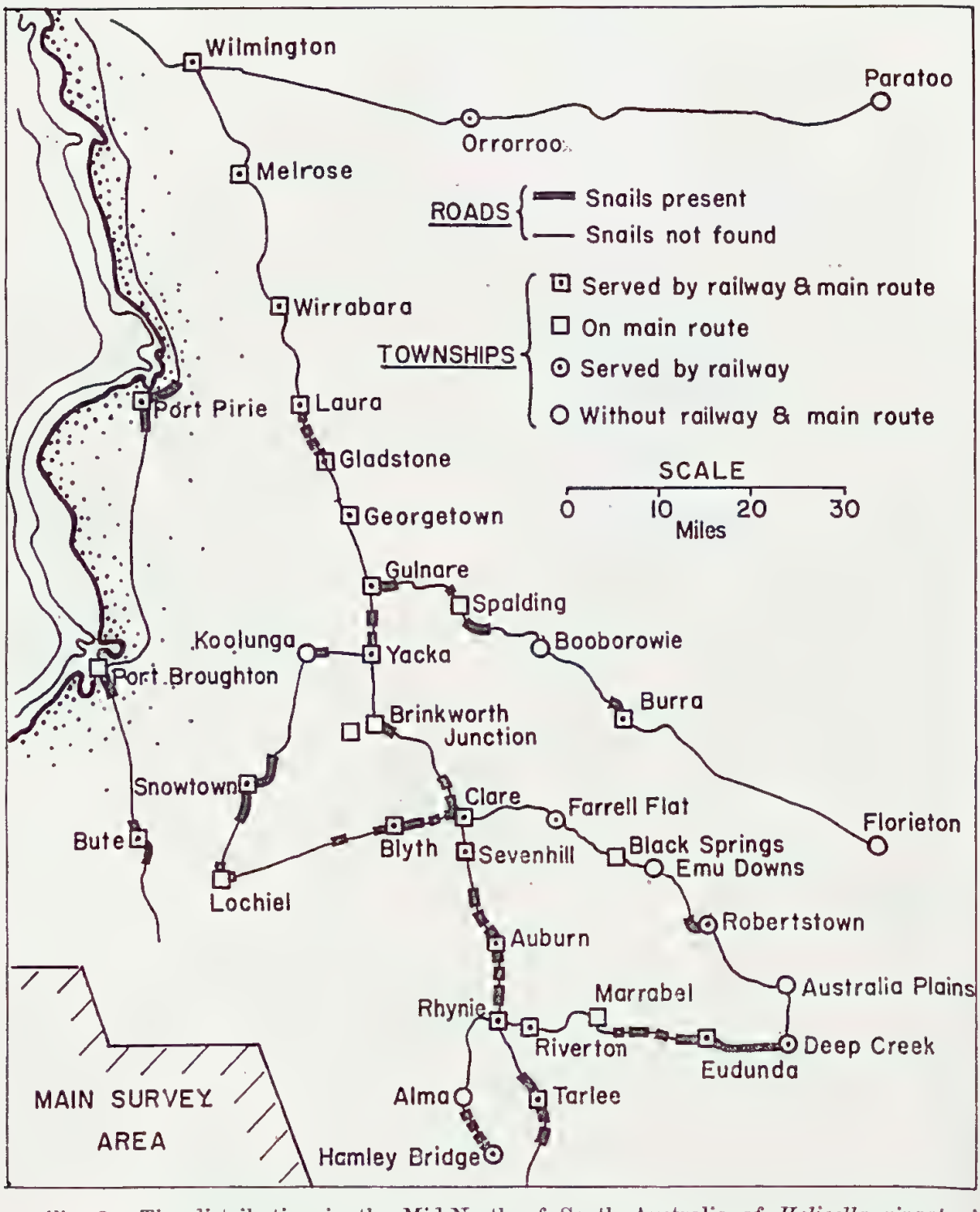


Fig. 3. The distribution in the Mid-North of South Australia of *Helicella virgata* in relation to transport routes.

for local dispersal particularly by farm vehicles, and subsidiary colonies may be started as around Clare, Rhynie and Eudunda. Eventually the colonies spread over all suitable country and coalesce as in most of the area shown in fig. 2. It seems clear that *H. virgata* is still spreading and it is probable that the spread will continue.

Relationships Between the Distribution of "H. virgata" and those of "H. neglecta" and of "Theba pisana".

Attention was earlier drawn to the confrontation in the distributions of *H. virgata* and *H. neglecta.* Many earlier records were based on mis-identification and are unreliable so that the sequence of events leading to the present situation is unknown. However, there are authentic records, based on South Australian Museum collections, of *H. neglecta* in the Moonta area, where it was apparently common earlier in the century, and where *H. virgata* is now abundant. Most early records for Yorke Peninsula seem to refer to *H. neglecta* and it is most likely that *H. virgata* has arrived more recently; *H. neglecta* was first recorded in the State much earlier than *H. virgata.* There is thus some evidence that the range of *H. neglecta* is contracting and considerable evidence that *H. virgata* is expanding its range but at present one can only speculate as to whether the two events are related.

In February, 1962, *H. virgata* was the dominant snail at Outer Harbour, a few miles north of Adelaide; in November of the same year *Theba pisana* appeared to be much more numerous. Four permanent quadrats were established there in August 1963, in an attempt to discover if these changes represented a continuous trend. Each quadrat was of 1 square metre and when first chosen, two were in areas where *H. virgata* was dominant, and two where *Theba* dominated. Only snails more than 5 mm. in diameter were recorded and quadrats were visited at approximately monthly intervals. Results for all four quadrats were similar and are shown in fig. 4; the proportions of *H. virgata* are also shown to facilitate comparisons.

T. pisana breeds later than *H. virgata,* its numbers reaching a peak several months after those of the latter species. The sizes of the large individuals of *T. pisana* were distributed bimodally, suggesting that the species takes two years to reach maximum size; *H. virgata* does so in one year. In spite of these complications, the overall numbers seem to show a trend in which *T. pisana* is increasing and *H. virgata* decreasing. In each case, where a comparison can be made between the two years, the population of *H. virgata* was lower in the second year.

H. virgata apparently does not eat green plants; *T. pisana* will, but the appearance of the Outer Harbour vegetation does not suggest heavy "grazing" and it is probably, like *H. virgata,* largely microphagous in its feeding habits. *T. pisana* may be superseding *H. virgata* by exploiting a limited resource—in this case, food—more effectively, and the observed changes in density could therefore be explained in terms of competition (in the restricted sense defined by Birch, 1957).

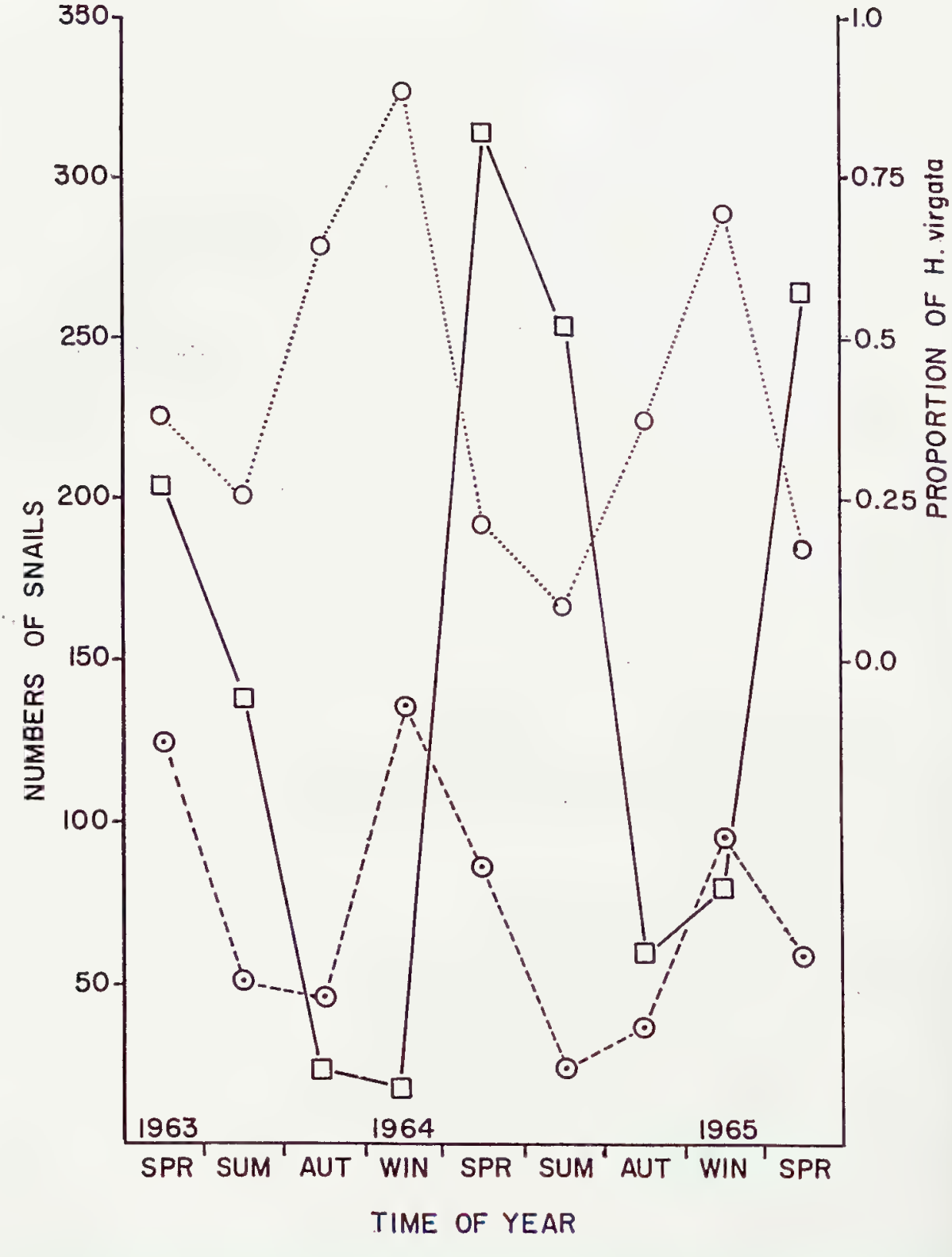


Fig. 4. Numbers of *Helicella virgata* and *Theba pisana* at Outer Harbour from 1963 to 1965. Numbers of *H. virgata*, ⊙ - - - ⊙; proportion of *H. virgata*, ○...○; numbers of *T. pisana*, □ — □.

However, there is insufficient evidence at present for this explanation to be considered as more than tentative.

The next decade or two may show interesting changes in the distribution and abundance of *H. virgata, H. neglecta* and *T. pisana* in South Australia.

THE IMPORTANCE TO MAN OF INTRODUCED SNAILS IN SOUTH AUSTRALIA

The introduction of animals to areas where they are not native, often has serious economic results; man is, in most cases, the agent responsible for the introduction, either intentionally or not.

Helix aspersa has become a serious pest on five continents, but in South Australia its ravages have so far, been limited mainly to gardens. The fact that it appears unable to survive in this State except under conditions of summer watering, may mean that here it can only become a pest of irrigated crops and market gardens; control is relatively simple on this scale. *Theba pisana* is, as yet, of no economic importance in this State; at present it is found most usually in uncultivated areas and the largest colony is probably that at Outer Harbour which extends for about 10 km. down the coast towards Grange. The many thousands of dollars spent on eradicating it from California (Basinger, 1927), and the major attempts to control it in South Africa (S. S. Walters, pers. comm.), suggest that it could become a serious problem here, and should therefore be regarded with caution. The same may apply to *Cochlicella ventrosa,* a species which is much addicted to seedlings. Like *T. pisana,* it is capable of surviving warm dry summers and might well become a pest of improved pastures and legume crops, as has happened in parts of South Africa (S. S. Walters, pers. comm.).

Helicella virgata is relatively harmless. It has, however, sometimes been numerous enough around Moonta (fig. 2) to cause trouble on barley crops. Snails aestivating on the ears may be threshed with the grain and the effect of large numbers of pulverised snails can be sufficient to raise the moisture content of the grain above the level acceptable for bulk storage. Observations in the area suggest that the problem is largely confined to the edges of the paddocks. The number of snails per ear (which exceeded 20 in some cases) fell rapidly, and except in a few instances there were rarely snails more than 10 or 20 metres from the boundary. Farmers found, however, that a horizontal bar placed in front of the reaping arms, knocked off most of the snails without seriously damaging the crop. *H. neglecta*

was, in a similar way, a serious pest to some of the barley growers in the southern part of Yorke Peninsula about 30 years ago but changes in agricultural practice have largely overcome the problem.

REFERENCES

Basinger, A. J., 1927: The eradication campaign against the white snail (*H. pisana*) at La Jolla, California. Mon. Bull. Calif. Comm. Hort., 16: 51-76.

Birch, L. C., 1957: The meanings of competition. Am. Nat., 91: 5-18.

Cotton, B. C., 1949: These snails may invade your garden. J. Agric. S. Aust., 1949: 561-565.

Ellis, A. E., 1926: British snails. Oxford Univ. Press, Oxford.

———— 1951: Census of the distribution of British non-marine Mollusca. J. Conch., Lond., 23: 171-244.

Laws, H. M., 1966: The cytology and anatomy of *Oxychilus alliarius* (Miller) (Mollusca, Zonitidae), a new introduction to South Australia. Rec. S. Aust. Mus., 15(2): 257-260.

Pomeroy, D. E., 1966: The ecology of *Helicella virgata* and related species of snails in South Australia. Thesis submitted for the degree of Doctor of Philosophy in the University of Adelaide.

Quick, H. E., 1952: Emigrant British snails. Proc. malac. Soc. Lond., 29: 181-189.

———— 1953: Helicellids introduced into Australia. Proc. malac. Soc. Lond., 30: 74-79.

Taylor, J. W., 1894-1921: Monograph of the land and fresh-water Mollusca of the British Isles. 4 vols., Taylor Bros., Leeds.

———— 1928: *Helix pisana* (Müll.) in South Australia. J. Conch., Lond., 18: 208.

Verco, Sir J., 1922: Record of a European mollusc not previously reported from Australia. Rec. S. Aust. Mus., 2(2): 221.

———— 1924: Record of European land molluscs introduced into South Australia. Rec. S. Aust. Mus., 2(4): 489-490.

ACKNOWLEDGMENTS

The detailed surveys of the distribution and abundance of *Helicella virgata* and *H. neglecta* and the study of the relationships between *H. virgata, H. neglecta* and *Theba pisana*, formed part of a thesis by the senior author for the degree of Doctor of Philosophy in the University of Adelaide; to Professor H. G. Andrewartha who supervised the thesis work, and to the many members of staff of the South Australian Museum who in their travels gathered snails and thereby helped extend our knowledge of the distribution of the exotic species, the authors extend their grateful thanks. They are also indebted to Mrs. J. Hope Black, Mrs. Julia Greenhill, and Mr. B. Campbell who assisted with information concerning the distribution of the snails in other States.

SUMMARY

Ten species of land snail are known to have become established in South Australia. The present distribution of these species in the State and their probable time of arrival are discussed. Detailed study is made of the distribution of *Helicella virgata* which occurs through much of the agricultural regions of the State including Northern Yorke Peninsula, and *H. neglecta* which is found only on Southern Yorke Peninsula. It is concluded that *H. virgata* is still extending its range in the State and that it may be replacing *Theba pisana* at Outer Harbour. The problem of *Helicella virgata* aestivating on barley ears has been overcome, as has the same problem with *H. neglecta*. *Helix aspersa* is a pest of gardens with summer watering. *Theba pisana* and *Cochlicella ventrosa*, both of which are widespread in the State, are serious pests in other parts of the world and both should be regarded with caution in South Australia.

THE CYTOLOGY OF SALINATOR SOLIDA (VON MARTENS), MOLLUSCA, AMPHIBOLIDAE

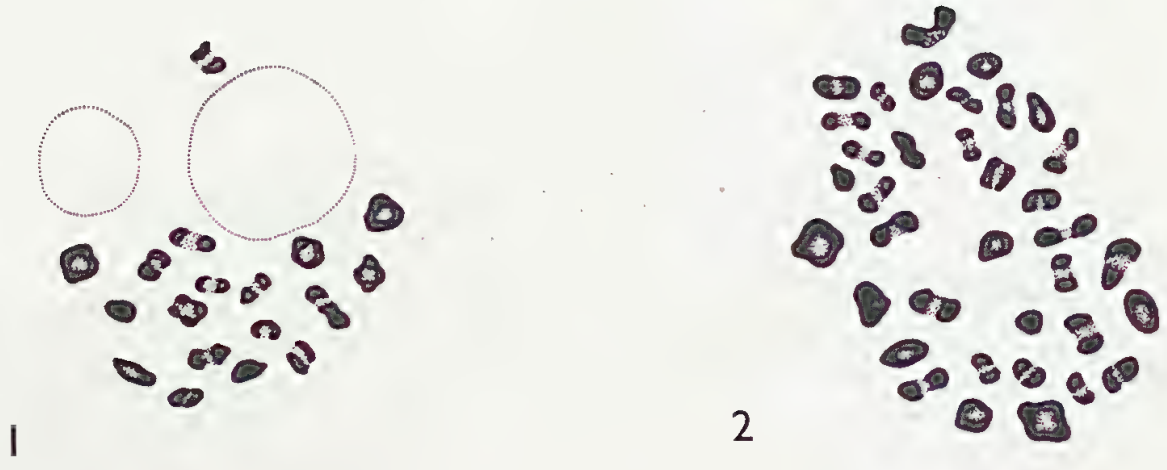
By HELENE M. LAWS, Curator of Marine Invertebrates, South Australian Museum

Salinator (Family Amphibolidae) belongs to the group of primitive basommatophoran pulmonates termed "Archaeopulmonata" by Morton (1955) and also including the Ellobiidae, Otinidae, Chilinidae, Latiidae, Gadiniidae and Siphonariidae. So few chromosome observations have as yet been made for members of "archaeopulmonate" families (see table I) that any additional records are of value. The majority of cytological observations for the Basommatophora have been made within Morton's second series which includes the remaining higher limnic families. Within these higher groups x = 18 is most common, occurring with a few exceptions in cytologically known members of the Physidae, Lymnaeidae (except *Radix* where n usually = 17), Planorbidae and Acroloxidae, although in the Ancylidae n = 15, 30, 60, 17, and 18 are known (Burch, 1962).

Salinator solida (von Martens) is common in mangrove and estuarine situations in Queensland, New South Wales, Victoria and South Australia. A collection of this species was made by D. E. Pomeroy from a brackish creek at Buckland Park, about 30 miles north of Adelaide in August, 1963. The snails were kept in shallow water in an aquarium for a number of weeks and individuals were taken from time to time for cytological study. Gonad samples were squashed in aceto-orcein, and voucher specimens are in the South Australian Museum collections D.14891.

Eighteen bivalents were present at meiosis of spermatogenesis (fig. 1). In most specimens there were, in the gonad, a few meiotic cells in which n = 36 (fig. 2), but this was never found to be the rule for any individual and it must be assumed that if any diploid sperm did arise, it was very unlikely to result in a viable snail.

The chromosome complement of n = 18 found in *Salinator solida* is the same as that observed by Inaba (1953) for the Japanese species *S. takii*, the only other member of the Amphibolidae which has been studied cytologically. The same chromosome number is found in other "Archaeopulmonate" species with the exception of *Siphonaria* in which n = 16, and two members of the Ellobiidae. The ellobiids are without doubt the most primitive existing pulmonates and it is noteworthy that although n = 18 predominates in the family (see table I),



Figs. 1 and 2. Camera lucida diagrams of meiotic figures.
Fig. 1. Meiotic chromosomes of *Salinator solida* in a normal diploid cell; n = 18.
Fig. 2. Meiosis in a tetraploid cell; n = 36.

Pythia and *Cassidula* which are in the most primitive section of the Ellobiidae have n = 17. They share this number with all cytologically known members of the more primitive opisthobranch groups, lending support to Morton's view that there is close affinity between primitive opisthobranch and basommatophoran groups and that the subclauses Opisthobranchia and Pulmonata diverged after a common origin from some unknown prosobranch ancestor.

TABLE I
CHROMOSOME NUMBERS OF ARCHAEOPULMONATA
(Adapted from Burch, 1965)

Family.	Haploid chromosome number.	Number of species.
Siphonariidae	16	1
Amphibolidae	18	1
Ellobiidae	17	2
	18	4
Chilinidae	18	1
Latiidae	18	1

REFERENCES

Burch, J. B., 1965: Chromosome numbers and systematics in euthyneuran snails. Proc. First Europ. malac. Congr. 1962: 215-241.

Inaba, A., 1953: Cytological studies in molluscs. I. Chromosomes in basommatophoric Pulmonata. J. Sci. Hiroshima Univ., ser. B, div. 1, 14: 221-228.

Morton, J. E., 1955: The Evolution of the Ellobiidae with a discussion on the origin of the Pulmonata. Proc. zool. Soc. Lond., 125: 127-168.

Woolacott, L., 1945: The establishment of *Salinator fragilis* Lamarck and *Salinator solida* von Martens as two distinct species in Australia. Proc. R. zool. Soc. N.S.W. 1945: 35-38.

HETEROGAMASUS TRÄGÅRDH (ACARI: RHODACARIDAE), INCLUDING THE SUBGENUS EVANSSELLUS RYKE, stat. n.

By DAVID C. LEE, Curator of Arachnology, South Australian Museum

Text fig. 1-33

SUMMARY

Heterogamasus Trägårdh is redefined to contain two subgenera; *Heterogamasus* sens. str. from South America and *Evanssellus* Ryke from Australasia. A key is given for the identification of the five species. Two new species (*H.* (*H.*) *calcarellus* and *H.* (*E.*) *medusa*) are described, while the descriptions of the type-species (*H.* (*H.*) *claviger* Trägårdh), *H.* (*H.*) *spinosissimus* (Balogh) and *H.* (*E.*) *foliatus* (Ryke) are extended.

INTRODUCTION

The genus, *Heterogamasus,* was established by Trägårdh (1907) with *H. claviger,* a single male from the Falkland Islands, as the only species. Trägårdh suggested that the genus was closely related to *Gamasellus* Berlese and commented "the shape of the first pair of legs is a quite unparalleled feature". The first pair of legs are unusual in being long and as thick as the other legs, but mainly in possessing large, ventral spines. No species had since been added to the genus, but *Evanssellus foliatus* Ryke, 1961 and *Gamasellus* (?) *spinosissimus* Balogh, 1963 are similar to *Gamasellus* and have unusual first legs like *Heterogamasus.* I have, therefore, placed these two species and two new species in *Heterogamasus.*

All members of the genus have a reasonable number of characters in common and were collected in cool, wet, temperate areas between 38° and 54° South. In contrast to their similarities, the mites fall into two distinct morphological groups; one from South America and one from Australasia. *Evanssellus* Ryke, 1961, with the status of subgenus, is used for the latter, the former being the nominate subgenus. Some characters differentiating the subgenera have previously been "weighted" as important enough to separate genera within the Rhodacaridae. To support or contradict this is too much guess-work until it is possible to consider the large number of undescribed rhodacarid species and undescribed immature stages of named species. The similarities of the two subgenera to *Gamasellus,* with the unusual adaptation of leg I, which is sensory rather than ambulatory in

Gamasellus, but presumably in this case is also prehensile, is considered sufficient to group *Heterogamasus* and *Evanssellus* within one genus until more clearly indicated otherwise.

MATERIAL AND METHODS

Only the type material of *H. medusa* and the *H. foliatus* from Wellington, belonged originally to the South Australian Museum. One female paratype of *H. calcarellus* has since been given to the South Australian Museum by the British Museum (Natural History). The other type material of *H. calcarellus* belongs to the British Museum (Natural History). The paratype female and paratype male of *H. foliatus* were borrowed from the Institute of Zoological Research of Potchefstroom University. The holotype female of *H. spinosissimus* was borrowed from the Hungarian Natural History Museum, Budapest. The idiosoma and legs of the male holotype of *H. claviger* were borrowed from the Naturhistoriska Ricksmuseum, Stockholm.

The methods are as in Lee (1966) and the terminology is as in Evans and Till (1965) and Lindquist and Evans (1965), but individually labelled idiosomal setae in the figures are numbered as if their row was complete. The labelling of the ventral and lateral setae of the genu and tibia of leg I is as advised by Dr. G. O. Evans (personal communication, 1966).

Family RHODACARIDAE Oudemans, 1902

Genus **Heterogamasus** Trägårdh

Heterogamasus Trägårdh, 1907, p. 2. Type-species: *Heterogamasus claviger* Trägårdh, 1907, by monotypy.

Evanssellus Ryke, 1961, p. 17. *New synonymy.* Type-species: *Evanssellus foliatus* Ryke, 1961, by original designation.

This genus is confined to the *Rhodacarus*-group, mentioned by Evans (1963, p. 302), by the following characters. The leg chaetotaxy is of the type in which the setal formula of tibia I is usually (2-6/4-2). The apotele is three tined, with one tine reduced and without an associated hyaline flap. In the female the metasternal setae are on the sternal shield, except in *H. medusa* where they are absent. The genital shield is truncated posteriorly and separate from a ventrianal shield. In the male there is a distally free spermodactyl and an armed leg II.

Heterogamasus can be separated from all other rhodacarid genera by having large, spine-like av_2 and pv_2 on tibia I.

The following further characters are probably also shared by the whole genus. Few setae are simple in form. In most specimens, especially adult females, parts of the idiosoma and legs are covered with an exudate, which is not included in the drawings. A shallower, inner layer, which is also variable and hyaline, often forms a flap on the setae and appears to continue over the setal bases and onto the general body surface. This second layer, where it occurs on the setae figured below, has been drawn with a broken line.

Female. Gnathosoma. Anterior margin of tectum curves forward to central spine with multidenticulate margin. Six or seven rows of deutosternal denticles. Third pair of hypostomal setae noticeably longer than others. Palpgenu seta, al_1, at least slightly pilose. Ventral setae on palptrochanter and lateral setae on palpfemur somewhat spine-like, v_1 on the former is slightly pilose and *al* on latter is short.

Idiosoma. Two dorsal shields; posterior one discrete, anterior one fused anteriorly to peritrematic shield, which is fused posteriorly to exopodal IV. Single, discrete pair of prae-endopodal shields. Sternum only fused to endopodal II. Endogynial shield with convex, curved anterior margin. Genital shield discrete; anteriorly round and hyaline, posteriorly truncated. Ventrianal shield discrete. Dorsal chaetotaxy: 6*j*, 6*z*, 5*s*, 5*r*; 5*J*, 5*Z*, 5*S*, 6*R*. In *H. spinosissimus* there are also 3*UR*. Ten to 13 setae on venter, plus a pair of paranals and an unpaired postanal. Jv_1 and Zv_1 small and setose, while some other setae on ventrianal shield always larger and differing in form.

Legs. Anterior legs larger than posterior legs. Chaetotaxy as in *Ologamasus* (see fig. 1, Lee (1966)), except on genu III and tibia III of *Heterogamasus* sens. str.

Male. Chelicerae have three teeth on fixed digit and one tooth on movable digit. Spermodactyl similar in shape to digits, but with dorsal groove. Peritrematic shield fused to ventrianal shield. Leg II is armed, but in *H. medusa* only *av* on femur is slightly modified to a spur.

Deutonymph. Both dorsal shields discrete. Chaetotaxy as adult, but some differences in idiosomal setal form.

Protonymph. Dorsal chaetotaxy; 6*j*, 3*z*, 2*s*, 4*r*; 5*J*, 5*Z*, 4*S*, 1*R*. Eight or seven pairs of setae on venter, plus a pair of paranals, an unpaired postanal and a pair of minute euanals. On genu I and tibia I, the anterior spine-like seta is *al* (note that only on genu I of the deutonymph and adult of *Evanssellus* is it also a lateral seta).

KEY TO *HETEROGAMASUS* SPECIES

Since there are few species, and in *Heterogamasus* sens. str. only one sex in each case, I have chosen characters which, it is hoped, apply to both males and females.

1. Genu III and tibia III chaetotaxy is (2-4/2-2) and (2-3/2-2). Reduced ambulacrum I, with small claws but no pulvillus. Anterior spine on genu I is av_2. Vertical setae (*j*1) not on prominent protruberance — *Heterogamasus* sens. str. 2

   Genu III and tibia III chaetotaxy is (2-4/2-1) and (2-3/2-1). No ambulacrum I. Anterior spine on genu I is al_1. Vertical setae (*j*1) on prominent protruberance .. — *Evanssellus* 4

2. Dorsal setae short, *e.g.*, in row *J* setal length is well under half distance between setae .. — *claviger* Trägårdh

   Dorsal setae longer, *e.g.*, in row *J* setal length is about, or more than, half distance between setae .. .. — 3

3. Setae Zv_1, Jv_1, and row *R* on integument .. — *spinosissimus* (Balogh)

   Setae Zv_1, Jv_1, and row *R* on shields .. .. — *calcarellus* sp. n.

4. Metasternal setae (*st* 4) present. Most dorsal setae (all row *S*) leaf-like .. .. .. — *foliatus* (Ryke)

   Metasternal setae (*st* 4) absent. Most dorsal setae (all row *S*) tentacle-like .. — *medusa* sp. n.

Subgenus **Heterogamasus** Trägårdh

The three species belonging to this subgenus are from South America. The adults range in idiosomal length from 560μ to 640μ.

The following characters (adult female, unless otherwise stated) distinguish this subgenus from *Evanssellus*. Movable digit of chelicera has three or four teeth. Central tectum spine bifurcate at tip. Idiosoma convex dorsally and without anterior protruberance bearing vertical setae (*j*1). The second seta in row *r* is small, while in most rhodacarids it is larger than the surrounding setae. Postanal pad fused to ventrianal shield. Paranal setae level with or slightly posterior to anterior margin of anus. Peritrematic shield clearly reticulated, except for small area around coxa IV, past which it extends some way posteriorly. Leg I has pretarsus, plus small claws and, in the protonymph, a small pulvillus. Chaetotaxy of genu III and tibia

III is as in *Cyrtolaelaps* Berlese; *i.e.*, (2-4/2-2) and (2-3/2-2). The anterior spine on genu I and tibia I, which is lateral in the protonymph, is av_2 in the deutonymph and adult. On femur IV, pd_2 (*pd* on protonymph) is largest seta. Male genu II obviously armed, with *av* as a spur. Holoventral shield in male consisting of sternogenital, ventrianal and peritrematic shields; an unusual condition when ventrianal shield is not fused to dorsal shield.

Heterogamasus (H.) claviger Trägårdh

1907, *Heterogamasus claviger* Trägårdh, p. 2; text figs. 1 and 2; pl. I, fig. 1, 2, 3, 6 and 8.

I have before me the idiosoma and five legs of the single male of this species, which according to Dr. E. Kjellander (personal communication, 1965) is all of the mite still in existence.

Male. Fig. 1-5. Idiosomal length, 640μ

Dorsal plate has reticulations and dimples as shown over limited area in fig. 3; see pl. I, fig. 8 in Trägårdh (1907) for total distribution. Dorsal setae are short compared with other species, and, as in *H. spinosissimus,* some are on integument. Reticulations on holoventral shield absent from sternogenital area, and inside ridge running posteriorly from stigma. Five *Jv* and three *Zv* setae on side figured, but on left side the two most posterior setae are replaced by a single seta in the equivalent of a position midway between them; *i.e.*, ***Jv5*** is missing.

Locality. Falkland Islands: holotype male under stones, east of Port Stanley, 25th February, 1902, coll. by Swedish South Polar Expedition of 1901-1903.

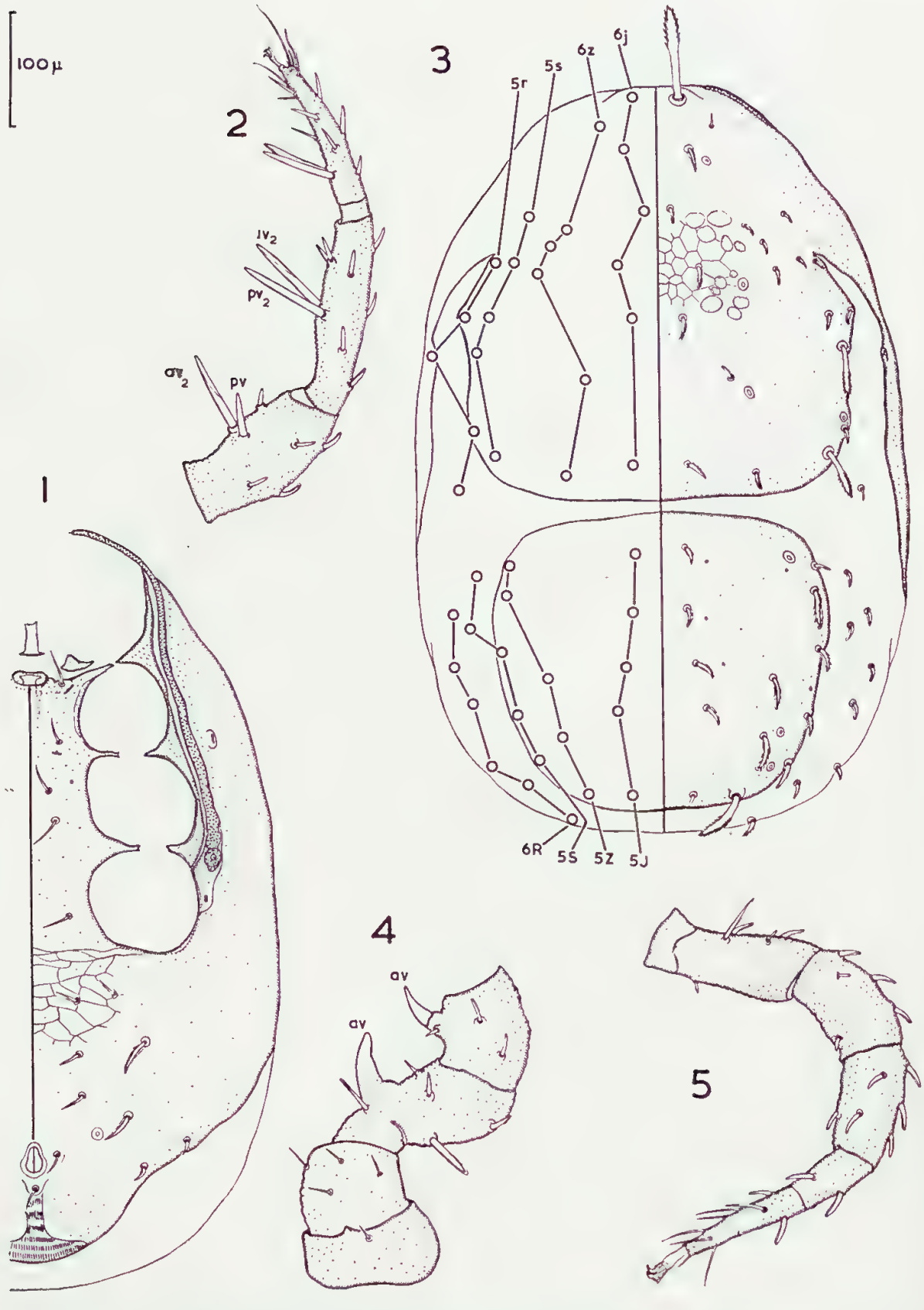
Heterogamasus (H.) spinosissimus (Balogh) comb. n.

1963, *Gamasellus* (?) *spinosissimus* Balogh, p. 489, fig. 18-23.

Female. Not figured. Idiosomal length, 560μ.

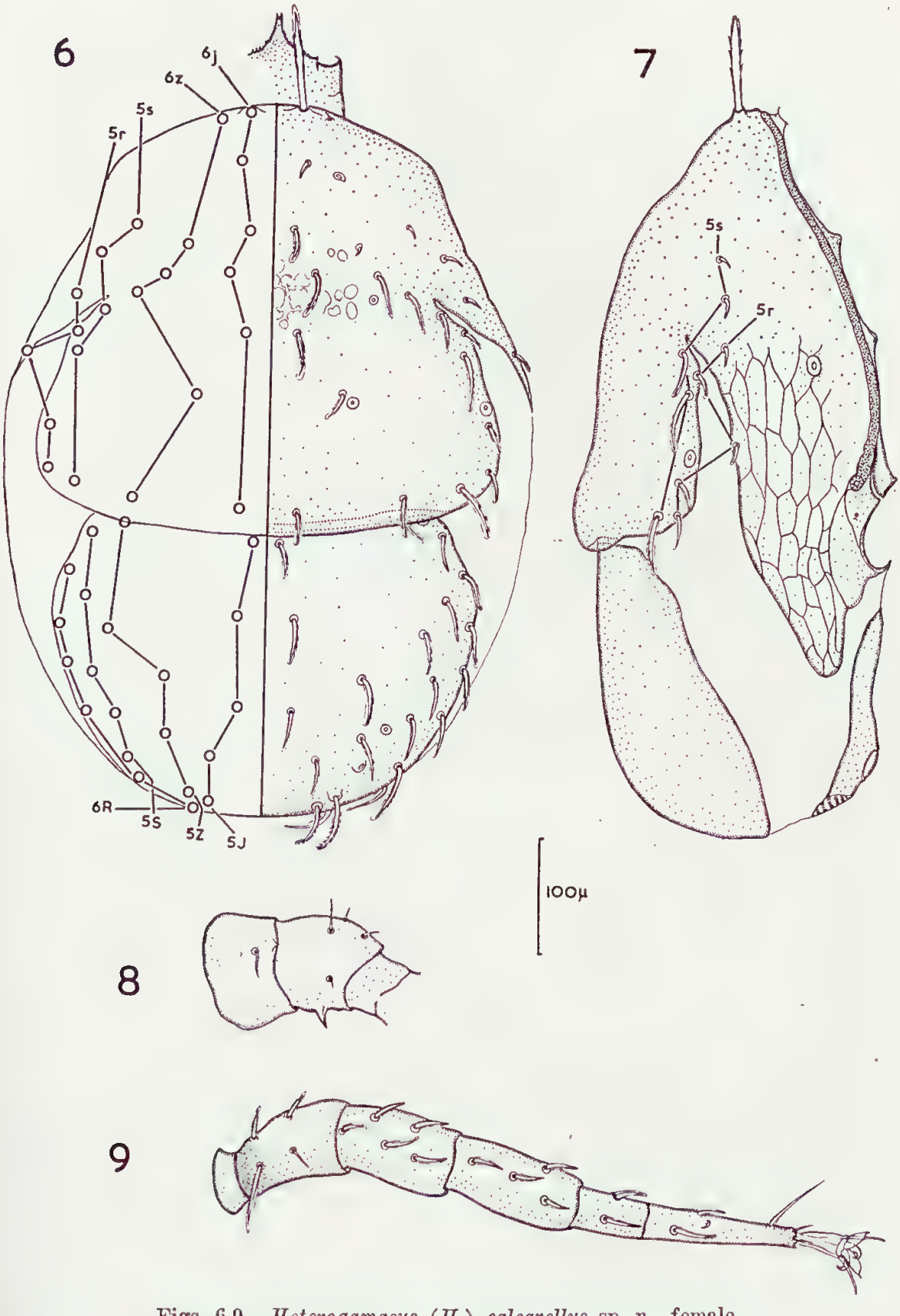
Three teeth on movable cheliceral digit. Having examined the holotype,, I regard the idiosomal chaetotaxy as *6j, 6z, 5s, 5r*; *5J, 5Z, 5S, 6R, 3UR*; *5st, 4Jv, 3Zv.* The *3UR* pairs of setae being the most posterior, peripheral setae on Balogh's drawing (1963, fig. 19) of the venter. The other characters are in accordance with those of the subgenus.

Locality. Argentina: holotype female, 1 paratype female, from sifted litter, *Maytenus boaris* forest with *Berberis darwini* and *Nothofagus antarctica,* near spring, 1,150 m., Mt. Piltriquitron, El Bolsón, Rio Negro, 16th November, 1961, coll. by Gy Topál.

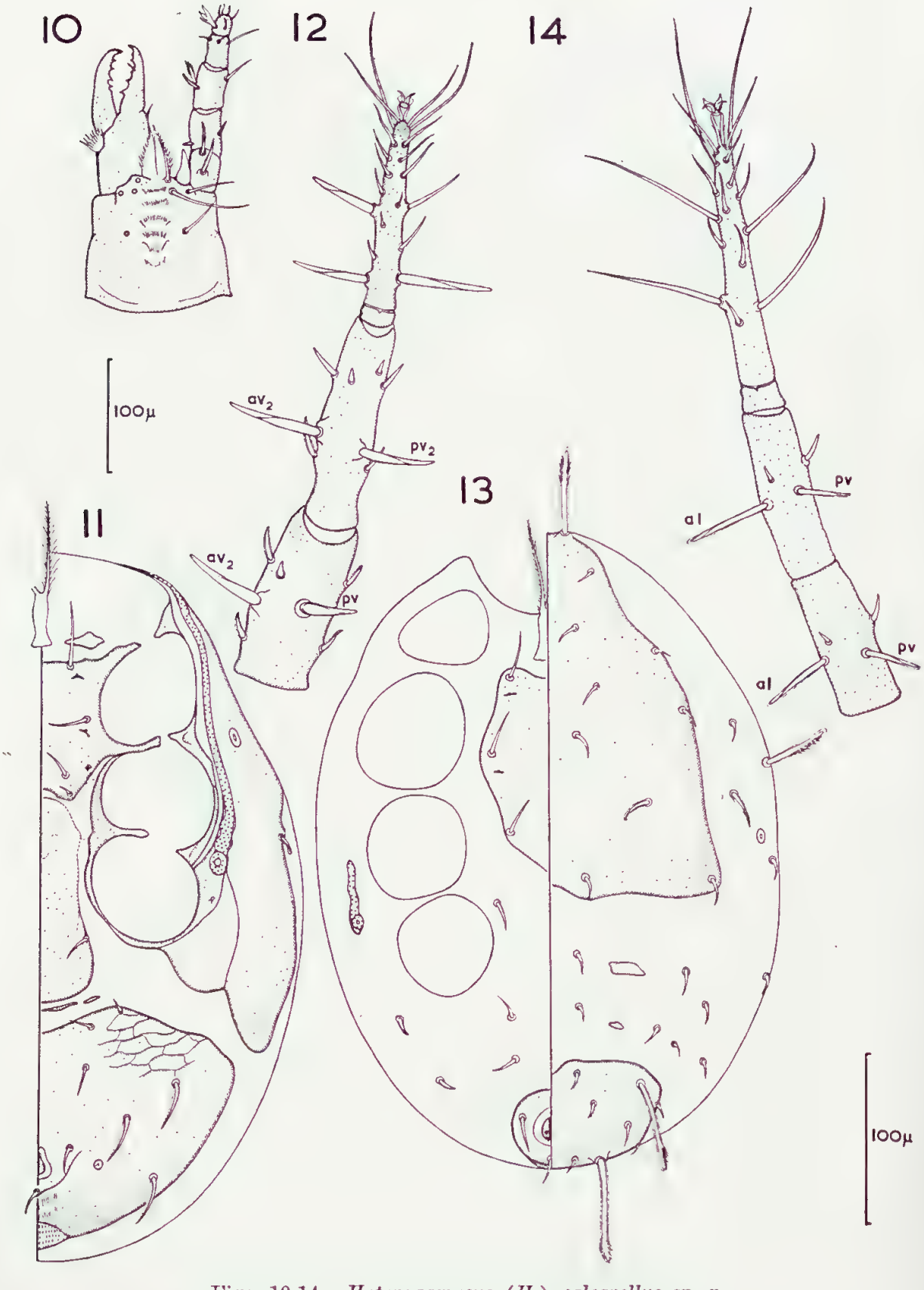


Figs. 1-5. *Heterogamasus* (*H.*) *claviger* Trägårdh, male.

1, venter; 2, distal segments from leg I; 3, dorsum; 4, proximal segments from leg II; 5, lateral view of distal segments from leg IV.



Figs. 6-9. *Heterogamasus* (*H.*) *calcarellus* sp. n., female.
6, dorsum; 7, lateral view of idiosoma; 8, ventral view of proximal segments from leg IV; 9, dorsal view of distal segments from leg IV.



Figs. 10-14. *Heterogamasus (H.) calcarellus* sp. n.
10-12, female. 10, ventral view of gnathosoma; 11, venter: 12, distal segments from leg I. 13 and 14, protonymph. 13, venter and dorsum; 14, distal segments from leg I.

Heterogamasus (H.) calcarellus sp. n.

Female. Fig. 6-12. Idiosomal length, 620μ.

Four teeth on movable cheliceral digit. Reticulations on peritrematic and ventrianal shields, but dorsal shields have only irregular dimples. The split between the peritrematic and anterior dorsal shield terminates just anterior to *s*3, as it does in *H. spinosissimus.* All idiosomal setae are normally on shields, but paratype female 2 has one *Zv*1 on integument of right side. The spines on leg II are very well developed. On trochanter IV, *p*1 is a small spur. Holotype female contained smooth, oval, unpigmented egg, 260μ x 200μ (length is nearly 42% of the length of the female idiosoma).

Protonymph. Fig. 13 and 14. Idiosomal length, 400μ.

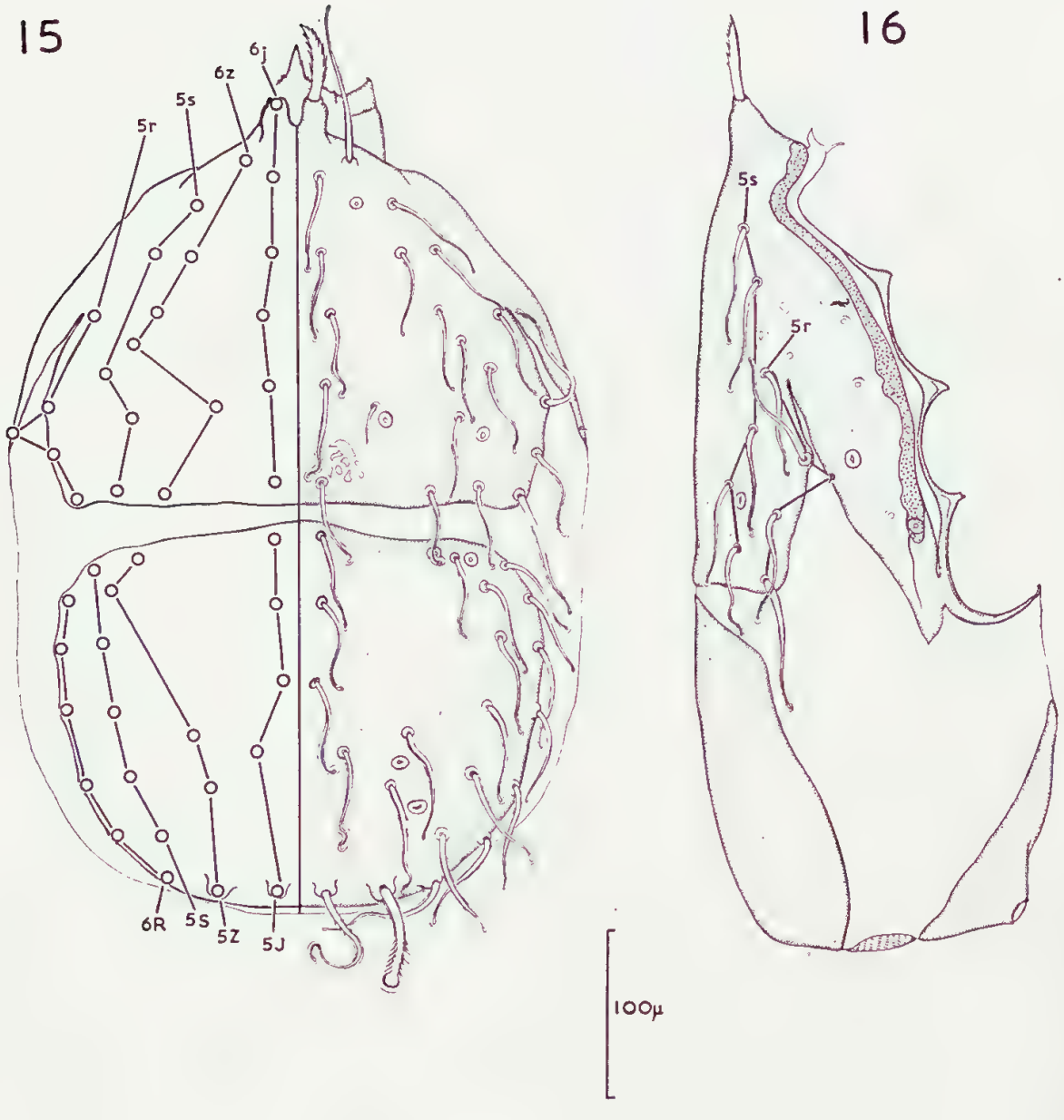
Chaetotaxy as in *H. medusa,* except that it is normal in having setal pair *st*5 present. Unlike the female, *r*2 is large and similar to *j*1. *Jv*3 and *Zv*1 are slightly spine-like compared with other ventral setae.

Locality. Tierra del Fuego: holotype female, morphotype protonymph, two paratype females from *Nothofagus* forest litter, Cordillera Darwin, 27th February and 1st March, 1962, coll. E. Shipton.

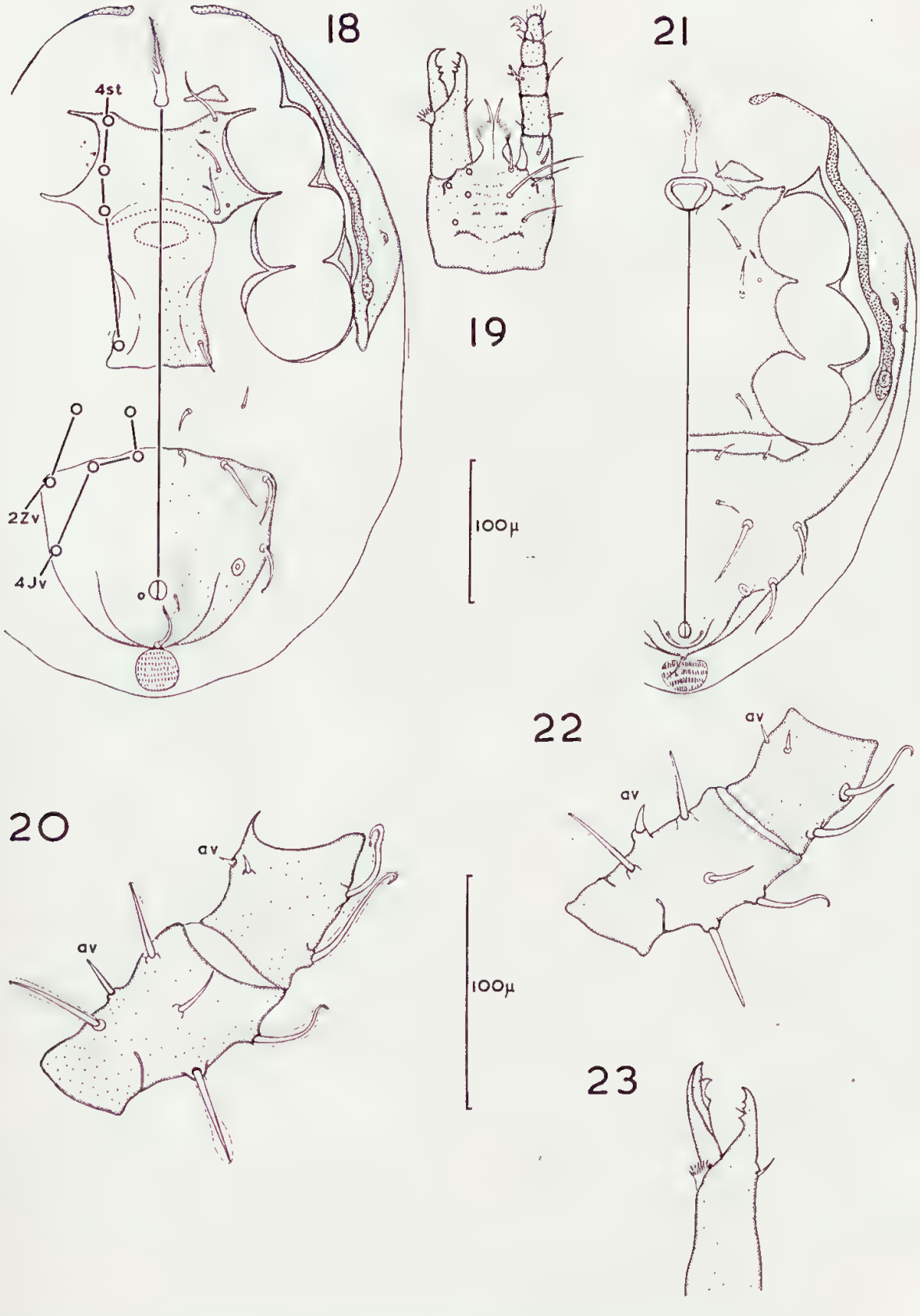
Subgenus **Evanssellus** Ryke, stat. n.

The two species, including a form of one species, are from Australasia. The adult range in idiosomal length from 420μ to 540μ.

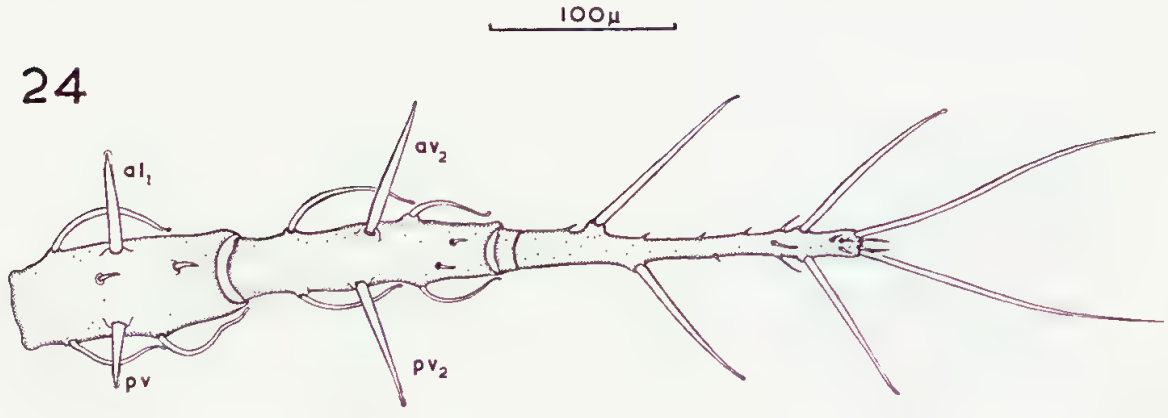
The following characters distinguish this subgenus from *Heterogamasus* sens. str. Movable digit of chelicera has two teeth. Central, tectum spine has single point at tip. Idiosoma flat dorsally, with anterior protruberance bearing vertical setae (*j*1). Postanal pad discrete. Paranal setae nearly level with posterior margin of anus. Peritrematic shield not reticulated, only markings are pits, that look similar to setal bases and in *H. foliatus* are mostly in a single line. Leg I has no pretarsus or ambulacrum in the adults or nymphs. Chaetotaxy of genu III and tibia III as in *Gamasellus*; *i.e.,* (2-4/2-1) and (2-3/2-1). The anterior spine on genu I of deutonymph and adult is lateral (*i.e.,* al_1), as in the protonymph, but on tibia I it is av_2 as in the adult of *Heterogamasus* sens. str. On femur IV, pd_2 (*pd* in protonymph) is much smaller than anterior dorsal setae. Male genu II not obviously armed, although *av* may be on a slight protruberance. May be holoventral shield in male as in *Heterogamasus*, or sternogenital shield can be separate from ventrianal shield, but peritrematic shield is always fused to ventrianal shield, which is still unusual when ventrianal shield is not fused to dorsal shield.

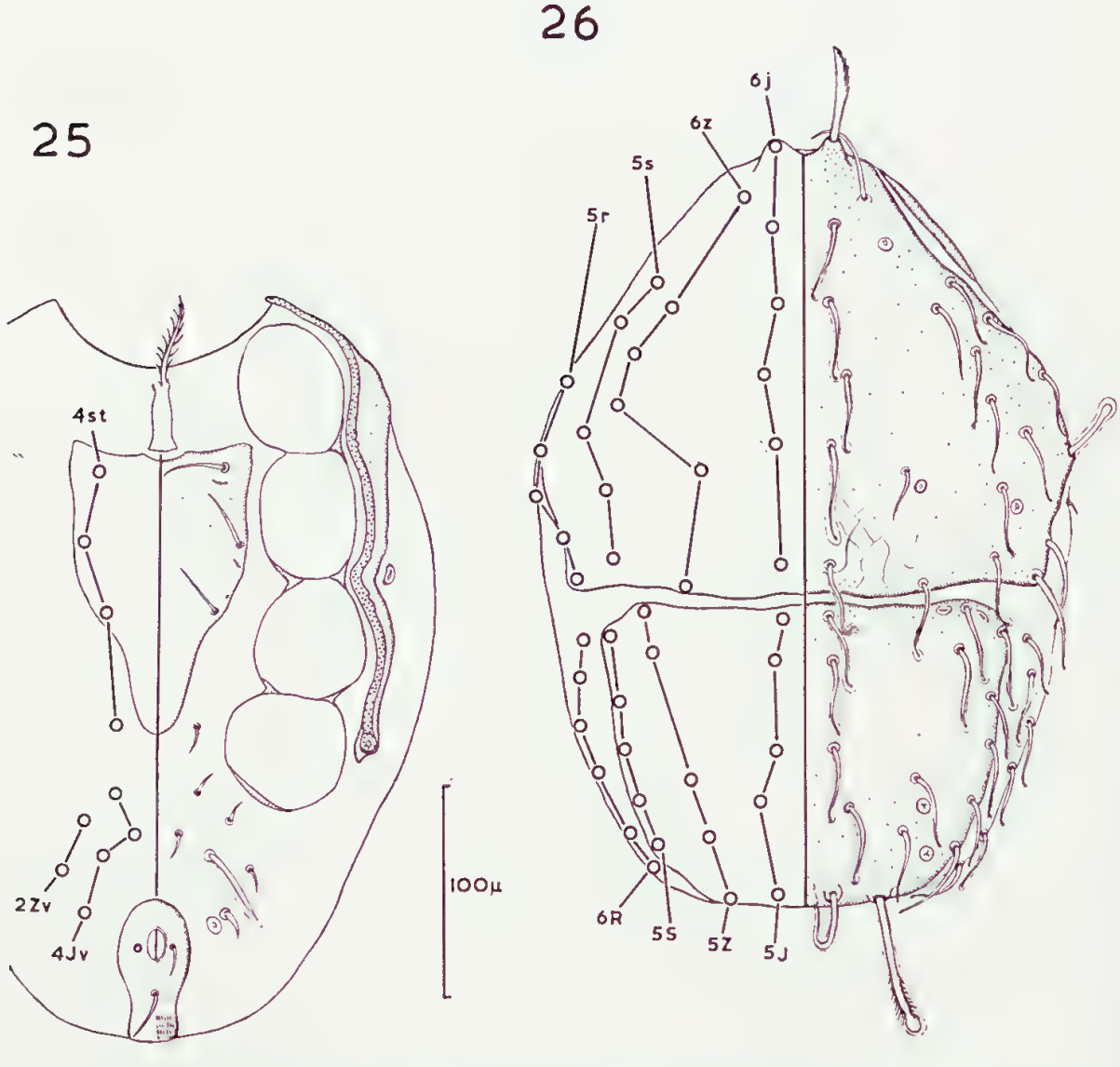


Figs. 15-17. *Heterogamasus* (*Evansscllus*) *medusa* sp. n., female.
15, dorsum; 16, lateral view of idiosoma; 17, dorsal view of distal segments from leg IV.

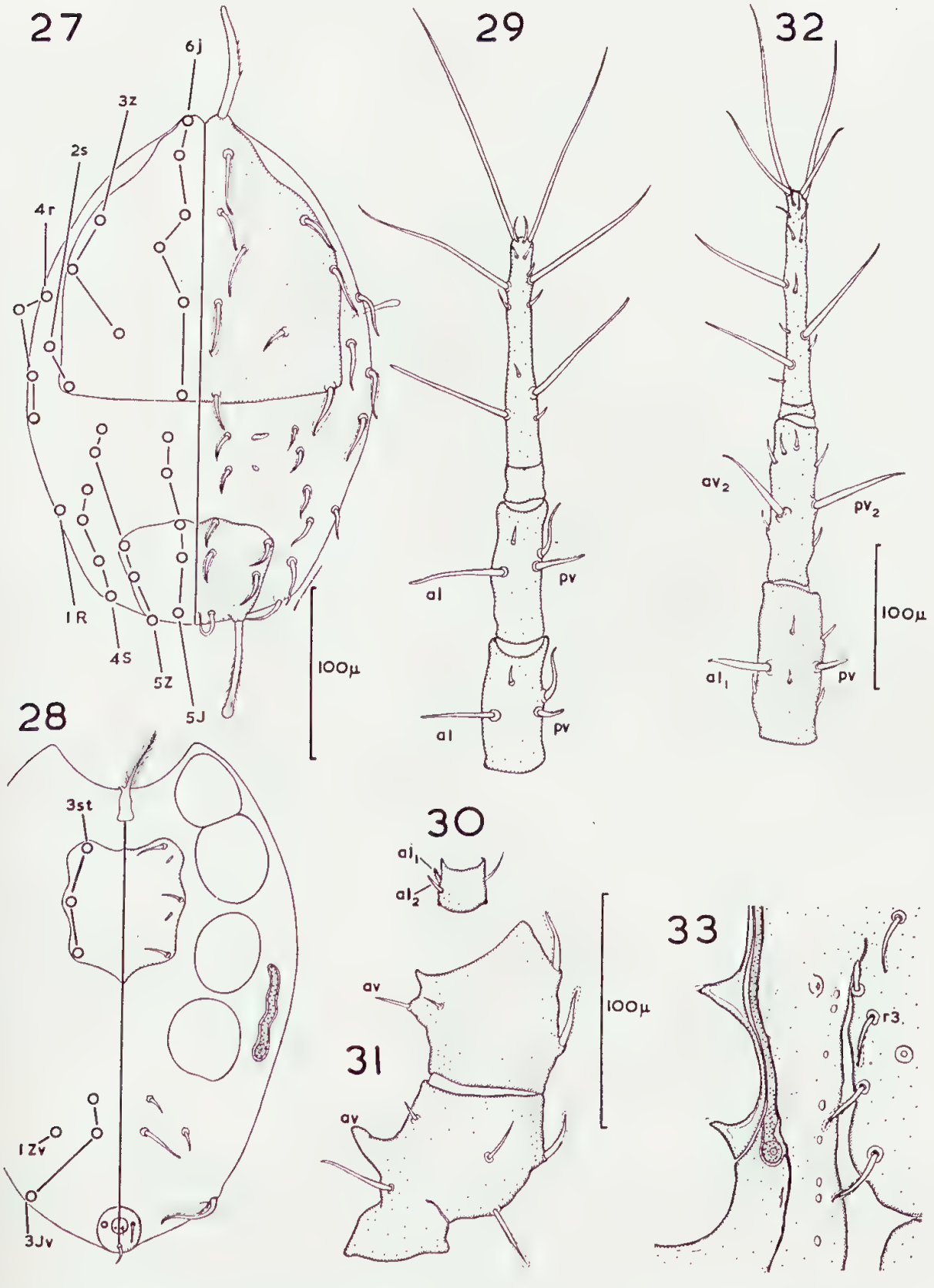


Figs. 18-23. *Heterogamasus* (*Evanssellus*) *medusa* sp. n.
18-20, female. 18, venter; 19, ventral view of gnathosoma; 20, femur II and genu II. 21-23, male. 21, venter; 22, femur II and genu II; 23, chelicera.





Figs. 24-26. *Heterogamasus* (*Evanssellus*) *medusa* sp. n.
24, female, distal segments from leg I. 25 and 26, deutonymph. 25, venter; 26, dorsum.



Figs. 27-33. 27-29, *Heterogamasus* (*Evanssellus*) *medusa* sp. n., protonymph. 27, dorsum; 28, venter; 29, distal segments of leg I.

30-33, *Heterogamasus* (*Evanssellus*) *foliatus* (Ryke), male. 30, palpgenu; 31, femur II and genu II; 32, distal segments of leg I; 33, area around stigma.

Heterogamasus (Evanssellus) foliatus (Ryke) comb. n.

1961, *Evanssellus foliatus* Ryke, 3, p. 245, fig. 1-9.

I have before me a paratype female and a paratype male from South Island and a female and three males from North Island, New Zealand. There are small differences between the mites from North Island and the types, but until more specimens are seen they are given infrasubspecific rank. The figures, and the description unless otherwise stated, are of the northern form.

Female. Idiosomal length, 520μ (paratype female, 540μ).

Besides slight differences in chaetomorphy, the northern form differs in *r*3 being on the dorsal shield instead of the peritrematic shield as in the paratype and the other *Heterogamasus* species. This female contains a larva, the claws and setae of which can be seen, suggesting that it is larviporous.

Male. Fig. 30-33. Idiosomal length, 440μ.

The movable digit of chelicera is shorter than fixed digit. On palpgenu al_1 is slightly pilose. As in female, *r*3 is on dorsal shield. In fig. 33 it can be seen that the setae in row *r* are not as leaf-like as in Ryke's (1961) drawing, which is true of the paratype to a lesser degree. Another difference is that *Z*4 in the northern form and paratype is subequal in length to the surrounding setae. Ryke (1961) compares the lateral fissure in the venter of the "*Ologamasus-Gamasiphis* group" males, with the ridge extending posteriorly from the *H. foliatus* stigma, when it should be compared with the broad fissure between the holoventral and dorsal shields. Seven large setae on tarsus I, of which four are terminal. Genu II has *av* on a small protruberance that is not present in the female.

Locality. New Zealand: type females and type males from beech litter, Queenstown, South Island, July, 1954, coll. not known; one female and three males from moss, Botanical Gardens, Wellington, North Island, 15th December, 1960, coll. D. C. M. Manson.

Heterogamasus (Evanssellus) medusa sp. n.

This species is unusual among the Rhodacaridae in that adults and nymphs have a pair of sternal setae missing. In the adults and deutonymph *st*4 is missing, but in the protonymph it must be *st*5 since *st*4 is not formed at this stage.

Female. Fig. 15-20 and 24. Idiosomal length, 470μ.

Faint, irregular markings on dorsal shield. All dorsal, idiosomal setae are on shields. Most dorsal setae are tentacle-like. Lateral setae *r*3 is very small. The ventrianal shield terminates anteriorly some way behind genital shield, leaving Jv_1 and Zv_1 on integument. There are six large setae on tarsus I, with two of them terminal.

Male. Fig. 21-23. Idiosomal length, 420μ.

The movable digit of the chelicera is longer than the fixed digit. Unlike the other two males the ventrianal shield is separate from the genitosternal shield. Leg II is hardly armed at all, *av* on femur being modified but still spine-like.

Deutonymph. Fig. 25-26. Idiosomal length, 380μ.

Unlike the adult, *r*2 is obviously different from the tentacle-like form of most of the dorsal setae. Otherwise besides changes in the shields on the venter, the deutonymph is like the adult.

Protonymph. Fig. 27-29. Idiosomal length, 310μ.

Chaetotaxy as shown in fig. 27 and 28. Chaetomorphy is also different from deutonymph. Dorsal setae not tentacle-like. *Jv*2 and *Jv*3 larger than other ventral setae.

Locality. Victoria, Australia: holotype female (LF79M1), allotype male (LF79M2), morphotype deutonymph (LF79M3), morphotype protonymph (LF79M4), four paratype females (LF79M5-8), and one paratype male (LF79M9), from moss and litter, among "tree ferns" and *Eucalyptus*, near Hordernvale, Cape Otway, 28th August, 1965, coll. F. J. Mitchell.

ACKNOWLEDGMENTS

I am indebted to Messrs. D. C. M. Manson, F. J. Mitchell and E. Shipton for collecting the unrecorded mites and to Dr. J. Balogh, Dr. G. O. Evans, Dr. E. Kjellander, Dr. K. Forsslund and Mr. G. C. Loots for making it possible for me to examine the recorded mites mentioned in this paper. Also, I would like to thank Dr. G. O. Evans of the British Museum (Natural History) and Mr. G. C. Loots of Potchefstroom University for their helpful correspondence, Miss Brenda Hubbard for assisting with the drawings, Mrs. J. C. Murphy for typing the manuscript, and Mr. R. Domrow for translating the German summary.

REFERENCES

Balogh, J., 1963: The Zoological results of Gy. Topál's Collectings in South Argentina. Annls. hist.-nat. Mus. natn. hung., 55: 487-496.

Evans, G. O. and Till, W. M., 1965: Studies on the British Dermanyssidae (Acari: Mesostigmata) Part I External Morphology. Bull. Brit. Mus. (nat. hist.) Zool., 13(8): 249-294.

Lee, D. C., 1966: New species of *Ologamasus* Berlese (Acari: Rhodacaridae) from Australia and New Zealand. Rec. S. Aust. Mus., 15(2): 205-235.

Lindquist, E. E. and Evans, G. O., 1965: Taxonomic concepts in the Ascidae with a modified setal nomenclature for the idiosoma of the Gamasina (Acari: Mesostigmata). Mem. ent. Soc. Can., 47: 1-64.

Oudemans, A. C., 1902: New List of Dutch Acari. Second Part: With remarks on known and descriptions of a new subfamily, new genera and species. Tijdschr. Ent., 45: 1-52.

Ryke, P. A., 1961: *Evanssellus*, a new genus of the family Rhodacaridae (Acarina: Mesostigmata). Acarologia, 3(3): 245-249.

Trägårdh, I., 1907: The Acari of the Swedish South Polar Expedition. Wiss, Ergebn. schwed. Subpolar-exped., 5(Zool)(11): 1-34.

ZUSAMMENFASSUNG

Heterogamasus Trägårdh wird redefiniert, und besteht aus zwei Untergattungen: *Heterogamasus* sens. str. aus Südamerika, und *Evanssellus* Ryke aus Australasien. Eine Bestimmungstafel für die fünf Arten wird beigefügt. Zwei neue Arten (*H.* (*H.*) *calcarellus* und *H.* (*E.*) *medusa*) werden beschreiben, und die Beschreibungen der Typenart (*H.* (*H.*) *claviger* Trägårdh), *H.* (*H.*) *spinosissimus* (Balogh) und *H.* (*E.*) *foliatus* (Ryke) erweitert.

ARADIDAE IN THE SOUTH AUSTRALIAN MUSEUM, ADELAIDE II. (HEMIPTERA-HETEROPTERA)

By NICHOLAS A. KORMILEV, Brooklyn, N.Y., U.S.A.

SUMMARY

The author describes three new genera, 19 new species and one new subspecies, all belonging to the subfamily Mezirinae Oshanin. They are as follows: *Mastigocoris malayensis* n. sp., Malay Peninsula; *Aspisocoris* n. g. for *A. termitophilus* n. sp., West Australia; *Artabanellus mcnamarai* n. sp., New Guinea; *Argocoris* n. g. for *A. grossi* n. sp., Queensland; *Aegisocoris* n. g. for *A. granulatus* n. sp., Queensland; *Neophloeobia tuberculata* n. sp., Queensland; *Artabanus bilobiceps papuasicus* n. ssp., New Guinea; *Artabanus truncatus* n. sp., New Guinea; *Artabanus tuberculatus* n. sp., Malay Peninsula; *Artabanus mcfarlandi* n. sp., Fiji; *Ctenoneurus aberrans* n. sp., New Guinea; *Pictinellus papuasicus* n. sp., New Guinea; *Pictinellus leai* n. sp., Fiji; *Pictinellus maturikiensis* n. sp., Fiji; *Pictinellus elongatus* n. sp., Fiji; *Pictinellus longiceps* n. sp., Fiji; *Pictinellus malayensis* n. sp., Malay Peninsula; *Mezira wilsoni* n. sp., Australia, Victoria and N.S.W.; *Mezira elegans* n. sp., Australia, N.S.W.; and *Mezira enigmatica* n. sp., New Guinea.

Mezira (*Mezirella*) *infantulus* Kiritshenko, 1959, previously placed by this author in the genus *Pictinellus* Usinger and Matsuda, 1959, is now transferred to the related genus *Glochocoris* Usinger and Matsuda, 1959.

The author does not agree with Blöte in synonymizing *Daulocoris auritomentosa* (Kormilev), 1955, with *Daulocoris feanus* (Bergroth), 1889, and gives differences for separation of these two species.

I want once more to express my sincere gratitude to Mr. Gordon F. Gross, Senior Curator of Invertebrates at the South Australian Museum in Adelaide, by whose kind offices I have been privileged to study the Aradidae in the rich collections under his care.

This paper treats the second and last section of the family sent to me for study, the subfamily Mezirinae Oshanin, 1908. The assemblage studied here proved to be no less interesting than the first*. Three genera, all from Australia, and 19 species are new, and are described elsewhere in this paper. Of particular interest is a new

* See: Nicholas A. Kormilev, Aradidae in the South Australian Museum, Adelaide (Hemiptera-Heteroptera); *Records of the South Australian Museum*, 1966, 15: 275-307.

termitophilous genus from West Australia, and two aberrant new species of *Ctenoneurus* Bergroth, 1887, and *Mezira,* A.S., 1843, respectively, both from New Guinea.

All measurements indicated in this paper were taken with a micrometer eyepiece, 25 units equalling 1 mm., with exception of *Argocoris grossi* n. sp., and *Aegisocoris granulatus* n. sp., in which 10 units equals 1 mm. The first figure in the ratio represents the length, and the second the width of the measured part. The length of the abdomen was taken from the tip of scutellum to the tip of hypopygium (♂), or segment IX respectively (♀), with the exception of *Aspisocoris termitophilus* n. g., n. sp., where it was taken on the ventral side.

Subfam. MEZIRINAE Oshanin, 1908

Gen. **Mastigocoris** Matsuda and Usinger, 1957

This genus was established on the base of a single male, but later Usinger and Matsuda mentioned that they have also seen species from Java and Sumatra (1959: 222).

1. **Mastigocoris malayensis** n. sp.

Male. Brachypterous. Similar to *Mastigocoris angulatus* Matsuda and Usinger, 1957, from which it differs by the rounded antero-lateral angles of pronotum, neither produced forward, nor sideways, and by the more protruding, and rounded, PE-VI. In the male, PE-II to PE-IV are not protruding, PE-V barely protruding, PE-VI distinctly protruding and rounded. In the female, PE-II to PE-VI are not protruding, PE-VII with a small tubercle, absent in male.

Measurements: head slightly shorter than width through the eyes, ♂—14:15.5, ♀—16:17.5; proportions of antennal segments, I to IV, are: ♂—7.5:5:7.5:7, ♀—7.5:5:7.5:7; pronotum less than half as long as maximal width, ♂—11:26, ♀—14:21; abdomen longer than maximal width across segment VI (♂), or V (♀), ♂—37.5:31, ♀—50:40.

Hemelytra with lateral border carinate basally; disc of corium with three divergent rows of finely granulate carinae (veins); hemelytra reach to $\frac{2}{3}$ of scutellum. Spiracles II to VI ventral, placed near the border, VII and VIII lateral and visible from above.

Colour: brown; tibiae and tarsi yellow-brown to yellow; round callous spots on central dorsal plate reddish brown.

Total length: ♂—3.0, ♀—3.84 mm.; pronotal width: ♂—1.04, ♀—1.24 mm.; abdominal width: ♂—1.24, ♀—1.60 mm.

Holotype: ♂, Malay Peninsula, Lenggong—A. M. Lea and party coll.; deposited in the South Australian Museum, Adelaide.

Allotype: ♀, collected with holotype; in the same collection.

Paratypes: 5 ♂, 11 ♀, and 3 nymphs, collected with holo and allotype; in the same and author's collections.

Aspisocoris new genus

Elongate, with parallel sides; upper surface covered with fine, setigerous granulation, setae erect and very short, giving the appearance of roughness.

Head as long as width across eyes; anterior process strong, constricted in the middle, and truncate in front, clypeus free, reaching to ¾ of antennal segment I. Antenniferous tubercles thick, blunt, reaching slightly beyond the base of ant. segment I. Eyes small, immersed in the head. Postocular borders straight, strongly converging backward; postocular tubercles absent. Vertex convex. Antennae moderately heavy; ant. segment I strongly incrassate, almost pyriform; II and III slightly tapering toward the base; IV cylindrical, rounded apically; II the shortest; I, III and IV subequal in length. Segment III and IV nearly half fused together (completely fused in nymphs). Rostral atrium open; rostral groove shallow, open posteriorly; rostrum reaching beyond fore border of prosternum.

Pronotum convex, half as long as its maximal width; fore border deeply sinuate; collar fused with disc. Antero-lateral angles angular, strongly produced forward, but not reaching eyes. Lateral borders subparallel, slightly convergent anteriorly; lateral notch absent; hind border angularly excavate. Disc divided into two lobes by a shallow depression; fore lobe twice as long as the hind lobe, triangularly raised in the middle, and depressed between median elevation and produced anterolateral angles. Hind lobe sloping backward, and towards the lateral margins.

Scutellum elongate triangular, strongly raised medially; basal border convex; lateral borders barely sinuate, and carinate; tip narrowly rounded, reaching almost to posterior border of tergum II; disc deeply depressed between median ridge and lateral borders.

Hemelytra reduced, but still separated into corium, clavus, and membrane; the latter abbreviated and without veins. Clavus appearing as a narrow triangle, and separated from corium by a deep sulcus. Corium longitudinally raised along clavus, and along exterior border, depressed between both elevations; its exterior border convex

anteriorly, and slightly sinuate posteriorly, reaching to the middle of connexivum II. Membrane rounded apically, reaching to the tip of scutellum. Hind wings absent.

Abdomen longer than maximal width. Lateral borders subparallel, slightly convex. Tergum I covered by scutellum in the middle, smooth, and separated from central dorsal plate by a distinct sulcus. Terga II to VI completely fused together, forming a rectangular, slightly convex plate, without any demarcation between segments. Fore and hind borders of central dorsal plate simple, not raised; lateral borders carinate. Disc, with exception of tergum II, which is smooth, covered with a setigerous granulation which is slightly finer than that of the head, pronotum, and scutellum. Tergum VII is different in both sexes: in the male, it is trapezoidal, with lateral borders converging posteriorly; disc raised posteriorly, without granulation, and with two (1 + 1) longitudinal ridges produced backward, and superimposed over hypopygium as acute spikes; these ridges are flat as seen from above, with sharp borders, tapering backward. In the female, tergum VII is also trapezoidal, slightly raised in the middle, and with a dense, setigerous granulation like the rest of body. Connexivum separated from tergum by a deep sulcus; connexiva slightly longer than their maximal width; discs slightly raised, and finely setigerously granulate (as fine as on central dorsal plate). PE-angles not protruding from II to VI; PE-VII forms an acute angle in the male, but is not produced and rounded in the female. Spiracles very small, II to VII ventral, placed well away from the lateral margins, VIII lateral and visible from above. Hypopygium large, subcordate, with a small, triangular ridge on the upper side medially, longitudinally depressed along the ridge. Paratergites small, clavate, adjacent to hypopygium. In the female, paratergites short, but wide, rounded posteriorly, reaching to the middle of segment IX.

Metathoracic scent gland openings in the shape of a thin, short canal placed just over the middle acetabula. Tergal scent glands seen as almost obliterated scars between III and IV, and between IV and V segments. Meso- and metasternum with a wide, shallow depression medially, which is prolonged on to sternum II. Sternum III with a median, triangular, low, and thin, carina. Sterna with straight posterior borders; in the male, sternum VII twice as long as VI. In the female, posterior border of sternum VI twice sinuate, similar to *Neuroctenus*; valves of VIII raised, forming a double carina.

Legs unarmed; trochanters semifused with femora; arolia present.

Type species: *Aspisocoris termitophilus* n. sp.

Aspisocoris n. gen. with its open rostral atrium, and abbreviated hemelytra, runs in Usinger and Matsuda's key to *Artabanellus,* but is far from it systematically. It is quite unique in the Mezirinae by virtue of the very long scutellum, and the completely fused together segments of the central dorsal plate, which form a rather flat, slightly convex plate.

1. **Aspisocoris termitophilus** n. sp.

Fig. 1-2

Male. Elongate, rather convex; brachypterous.

Measurements: head as long as width across the eyes; ♂—21:21, ♀—20:20.5; proportions of antennal segments, I to IV, are: ♂—7.5:5:7:7, ♀—7.5:4.5:5.5:7. Pronotum half as long as its maximal width: ♂—16:31, ♀—16:32.5; scutellum longer than basal width: ♂—25:20, ♀—27:20; abdomen (measured on ventral side because of the length of scutellum) longer than its maximal width: ♂—50:38, ♀—53:38; hypopygium shorter than its maximal width: 15:23.

Colour: testaceous; tips of antennal segments IV, tergum II, and the middle of ventral side, from prosternum to sternum VI, lighter, yellow brown to pale yellow brown.

Total length: ♂—4.08, ♀—4.52 mm.; width of pronotum: ♂—1.24, ♀—1.30 mm.; width of abdomen: ♂—1.52, ♀—1.52 mm.

Holotype: ♂, West Australia, Mundaring—J. Clark coll., in a termite nest; deposited in the South Australian Museum, Adelaide.

Allotype: ♀, collected with holotype; in the same collection.

Paratypes: 2 ♂, 7 ♀ and 11 nymphs, collected with holo- and allotype; in the same, and author's collection.

Gen. **Artabanellus** Matsuda and Usinger, 1957

Artabanellus Matsuda and Usinger was established on the basis of a single female specimen, from Palau Islands; the specimen described here, also a female, is from New Guinea (Papua).

1. **Artabanellus mcnamarai** n. sp.

Female. Ovate, micropterous; all elevations on the head and body covered with rufous curled hairs.

Head slightly shorter than width through the eyes (23:25). Anterior process long, with parallel sides, notched at the tip, reaching to $\frac{3}{4}$ of antennal segment I. Antenniferous tubercles dentiform, their exterior borders subparallel, reaching to $\frac{1}{4}$ of antennal segment I. Eyes moderately large, protruding. Postocular tubercles absent;

postocular borders slightly convergent posteriorly. Vertex with a high median ridge, covered with curled hairs. Antennae less than twice as long as head (38.5:23); segment I thick, clavate, II narrower, slightly tapering toward the base, III subcylindrical, also slightly tapering toward the base, IV fusiform. Proportions, I to IV, are: 10:6:13:9.5. Rostral atrium open; rostrum short, does not reach to the base of rostral groove.

Pronotum $\frac{1}{3}$ as long as its maximal width (15:43). Collar fused with disc; laterad of it are placed two (1 + 1) small tubercles; antero-lateral angles are extended into reflexed, rounded lobes; lateral borders convex; hind border broadly convex. Disc with two (1 + 1) moderately large tubercles placed laterad of median line, and with two (1 + 1) high tubercles placed near postero-lateral angles; from these tubercles run mesad, along posterior border, two (1 + 1) thin, low carinae, evanescent before reaching each other.

Scutellum elevated in the form of a hump, shorter than width at the base (16:23); lateral borders straight, tip rounded.

Hemelytra reduced to small vertical pads.

Metanotum split into two (1 + 1) large plates, elevated in the middle.

Abdomen shorter than maximal width across segment II (58:62). Tergum I split by scutellum into two (1 + 1) transverse plates. Central dorsal plate consisting of terga II to VI; median portion raised as a wide, moderately high ridge; the latter more raised at hind borders of terga II, IV and VI. Laterad of median ridge disc is more or less flat, with the exception of two (1 + 1) short longitudinal ridges placed on terga III and IV laterally. Tergum VII depressed in the middle, raised at postero-lateral angles. Connexivum wide and reflexed. PE-II to PE-IV not protruding, PE-V to PE-VII progressively protruding as rounded tips. Paratergites conical, produced further than IX; the latter is placed at lower level than paratergites, and truncate posteriorly. Spiracles II to VI ventral, placed far from the border; VII and VIII lateral and visible from above. Lateral borders of abdomen are subparallel, but because of reflexion they appear to converge backward.

Legs unarmed; trochanters free.

Colour: sepia to black; body covered with thin incrustation and dirt. Antennae, rostrum, legs, and some parts of body are greyish brown.

Total length, 4.56 mm.; width of pronotum, 1.72 mm.; width of abdomen, 2.48 mm.

Holotype: ♀, New Guinea, N.E. Papua, Mt. Lamington—C. T. McNamara coll.; deposited in the South Australian Museum, Adelaide.

It is a pleasure to dedicate this species to Mr. C. T. McNamara who collected so many of the rare species of Aradidae represented in the collection.

Artabanellus mcnamarai n. sp. differs from *A. infuscatus* Matsuda and Usinger, 1957, by: (1) less converging postocular borders; (2) raised postero-lateral angles of pronotum; (3) vertically raised wing pads; and (4) abdomen with subparallel borders.

Gen. **Chelonoderus** Usinger, 1941

Chelonoderus Usinger as now understood includes only a single species from Queensland; the other two species previously attributed to this genus were transferred by Usinger and Matsuda to two different genera (1959: 230): for *C. hackeri* Drake, 1942 they erected the genus *Drakiessa* Usinger and Matsuda, 1959, and the second, *C. basilewskyi* Hoberland, 1956, from Africa, belongs to another genus, yet to be described.

1. **Chelonoderus stylatus** Usinger

Chelonoderus stylatus Usinger, 1941, Pan-Pacific Ent., **17**: 180, fig. 3.

1 ♂ and 3 ♀, Australia, Northern Territory, Port Darwin—W. D. Dodd coll.; 2 ♂, Queensland, Mulgrave R.—Hacker coll.; 1 ♂ and 1 ♀, Queensland, Cairns Distr.—W. D. Dodd coll., and 1 ♀, Cairns Distr.—Darlington coll.

Argocoris n. gen.

Ovate. The upper surface, particularly the head and pronotum, covered with rough rugulosities and tubercles. Apterous.

Head as long as width through the eyes; anterior process strong, constricted in the middle, wide in front, and slightly notched, genae much longer than clypeus, and contiguous, produced slightly beyond the tip of antennal segment I. Antenniferous tubercles strong, dentiform, blunt, slightly divergent, reaching to the middle of antennal segment I. Eyes semiglobose, protruding, but not stylate. Postocular tubercles small, blunt, not reaching to outer border of eyes. Vertex raised and covered with rough tubercles. Antennae slender; segment I clavate, slightly curved outward, II half as long as I, others missing. Rostral atrium closed; rostrum short, not reaching to hind border of rostral groove; the latter wide and deep, open posteriorly.

Pronotum $\frac{1}{3}$ as long as its maximal width; collar raised and distinctly separated from disc; antero-lateral angles inflated, robust

and produced forward, and slightly inward, though not reaching to fore border of collar. Lateral borders slightly convex; hind border convex in the middle, sinuate laterally. Disc with a very deep median sulcus, flanked by two (1 + 1) high ridges, covered with rough tubercles, and bearing an "L"-shaped callosity.

Mesonotum slightly wider than pronotum; median ridge high, with a deep longitudinal sulcus, covered with rough tubercles. Laterad of median ridge, opposite to ridges of pronotum, are placed two (1 + 1) smaller, robust subtriangular ridges, directed backward, but not reaching to hind border of mesonotum; mesad of lateral borders are placed two (1 + 1) robust, ovate ridges. Apexes of metathoracic scent gland openings visible on lateral margins. Around median ridges are placed wide, deep, and irregularly shaped, depressions.

Metanotum slightly narrower than mesonotum, separated from lateral borders by connexivum II. In the middle it is raised and fused together with median ridge of mesonotum, and tergum I. Metanotum is raised laterally as an irregular, deeply punctured trapezoid. Between median ridge and lateral elevations disc deeply depressed.

Abdomen as long as its maximal width across segment IV. Lateral borders regularly convex. Tergum I raised, with a median sulcus, which is forked posteriorly, running along hind border. Suture between tergum I and central dorsal plate deep; the latter consisting of terga II to VI fused together and raised, forming a high plateau. Area of dorsal scent glands higher, forming a wide median ridge, surrounded by eight (4 + 4) deep, round depressions; sloping sides of plateau rugose with irregular, or S-shaped, carinae. Tergum VII also highly raised, but depressed in the middle, and posteriorly. Connexivum wide, and uneven; all segments clearly separated from each other; PE-angles not protruding; exterior borders straight from II to V, slightly sinuate on VI and VII. Spiracles II to VII ventral, placed far from the border; VIII lateral and visible from above. Paratergites (♀) short, in the form of tubercles, reaching to middle of a short, tricuspidate segment IX.

Prosternum with a high median ridge; meso- and metasternum depressed in the middle. Metathoracic scent glands with long, oblique canals. Venter with sterna rugose, punctured, depressed medially, and with six (3 + 3) rows of larger and smaller round, callous spots.

Legs unarmed; trochanters free; femora fusiform, as long as tibiae; claws without arolia.

Type species: *Argocoris grossi* n. sp.

Argocoris n. g. in Usinger and Matsuda's key runs to *Chelonoderus* Usinger, 1941, to which it is related, but differs by the different shape of body, the presence of small postocular tubercles, and in particular in the different topography of upper surface of the body.

1. **Argocoris grossi** n. sp.

Fig. 3-4

Female. Ovate, with very rugose upper surface, naked and shiny. Apterous.

Measurements: head as long as width through the eyes (21:20); proportions of antennal segments, I to II, are: 7:4:-:- (others missing). Pronotum much shorter than maximal width (10:31); mesonotal width—35, metanotal width—33; abdomen as long as maximal width 50:49.

Colour: reddish brown to dark brown; area of dorsal scent glands, antennae, rostrum, and trochanters, yellow brown.

Total length, 9.10 mm.; pronotal width, 3.10 mm.; abdominal width, 4.9 mm.

Holotype: ♀, Queensland, Bowen—A. Simson coll.; deposited in the South Australian Museum, Adelaide.

It is a pleasure to dedicate this species to Mr. Gordon F. Gross, Senior Curator of Invertebrates at the South Australian Museum, Adelaide.

Aegisocoris n. gen.

Ovate; apterous; very convex on upper surface, covered with ridges, protruberances, and round tubercles of different sizes; on salient portions partially covered with rust coloured hairs.

Head shorter than width through the eyes. Anterior process strong, constricted in the middle, widened in front and incised, genae being longer than clypeus and contiguous, reaching slightly beyond the tip of antennal segment I. Antenniferous tubercles stout, blunt, slightly divergent, reaching almost to the middle of antennal segment I. Eyes globose, slightly pedunculate. Postocular tubercles blunt, reaching to outer border of eyes. Postocular margins strongly convergent backward. Vertex with two (1 + 1) rows of strong tubercles; clypeus with much finer tubercles. Antennae slender; segment I clavate, II and III tapering toward the base, IV pyriform. Rostral atrium closed, placed far from the tip of the head. Rostrum reaching to hind border of a deep rostral groove which is closed posteriorly.

Pronotum very short and wide; collar thin, poorly separated from disc; anterior borders, slightly receding towards the sides; antero-lateral angles extended into small, rounded lobes, and reflexed; postero-lateral angles with high, round tubercles (1 + 1). Disc with two (1 + 1) high ridges which are divergent backward, each of them bearing two large tubercles; laterad of ridges disc covered with moderately large, round granules.

Mesonotum wider than pronotum; in the middle with a stout, high median ridge fused with tergum I posteriorly; median ridge bearing a longitudinal sulcus flanked by two (1 + 1) ridges; laterad of them with two (1 + 1) large, round tubercles opposed by two (1 + 1) others which are salient from fore border; further toward lateral borders disc flat, only hind border thinly carinate. On lateral borders are placed two (1 + 1) large tubercles, slightly inclined posteriorly; in front and somewhat lateral to these apices of metathoracic scent gland openings visible.

Metanotum slightly narrower than mesonotum, but wider than pronotum, separated from lateral borders by the forwardly produced connexiva II. Disc split into two (1 + 1) large, rather flat plates, bearing in the middle posteriorly a cluster of tubercles.

Abdomen ovate, shorter than maximal width across segment IV, and strongly elevated on central dorsal plate. Tergum I is strongly elevated and granulate in the middle, abruptly sloping laterally; it is separated from mesonotum and central dorsal plate by deep sulci. Central dorsal plate consists of terga II to VI fused together, forming a large hump. This hump in the middle, on terga II to IV, has a cross-shaped elevation, covered with rough, round granules, and behind it, on terga V and VI, a subtriangular ridge sloping backward. Disc of central dorsal plate covered with rough, round granules. Connexivum wide and horizontal; hind borders of connexiva II to VI carinate; PE-angles slightly protruding, rounded. Tergum VII strongly and rotundly elevated laterally, depressed in the middle and posteriorly; also covered with rough, round granules. Spiracles II to VII ventral, placed far from the border; VIII lateral and visible from above. Paratergites (♀) small, triangular, reaching to $\frac{1}{3}$ of segment IX, which is truncate posteriorly.

Prosternum with a longitudinal ridge; pleura and venter with rough, round granules. Venter strongly convex.

Legs unarmed; trochanters free.

Type species: *Aegisocoris granulatus* n. sp.

Aegisocoris n. gen. is related to *Drakiessa* Usinger and Matsuda, 1959, from which it differs by a different topography of the upper surface and rough round granules dispersed over the body.

1. **Aegisocoris granulatus** n. sp.

FIG. 5-6

Female. Strongly convex on upper surface, less so on lower; covered with smooth, shiny, round granules of different sizes.

Measurements: head shorter than width through the eyes (42:46); proportions of antennal segments, I to IV, are: 14:8.5:14:12; pronotum very short and wide (16:56); mesonotum wider than pronotum (75); metanotum narrower than mesonotum, but wider than pronotum (65); abdomen slightly shorter than maximal width (96:100).

Colour: black; antennae, rostrum, and legs, reddish brown; tarsi yellow brown; curled hairs ferruginous.

Total length, 7.12 mm.; width of pronotum, 2.24 mm.; width of abdomen, 4.0 mm.

Holotype: ♀, Queensland, Cairns district—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Gen. **Drakiessa** Usinger and Matsuda, 1959

1. **Drakiessa hackeri** (Drake)

Chelonoderus hackeri Drake, 1942, Pan Pacific Ent., **18**: 190.

Drakiessa hackeri Usinger and Matsuda, 1959, Class. Aradidae; p. 231.

7 ♂ and 7 ♀, Queensland, Mt. Tambourine—A. M. Lea coll.; 3 ♂ and 3 ♀, Queensland, Blackall Range—A. M. Lea coll.

2. **Drakiessa parva** Kormilev

Drakiessa parva Kormilev, 1965, Proc. Roy. Soc. Queensland, **77**: 24.

1 ♂, Queensland, Mt. Tambourine—A. M. Lea coll.

Gen. **Neophloeobia** Usinger and Matsuda, 1959

Neoploeobia was known from two species, both from Australia, here I describe a third, also from Australia. Usinger and Matsuda described this genus as *apterous*, but then later go on to speak about *hemelytra*. Actually *Neoploeobia* is micropterous, the hemelytra are present but reduced to very small pads.

1. **Neophloeobia montrouzieri** Usinger and Matsuda

Neoploeobia montrouzieri Usinger and Matsuda, 1959, Classif. Aradidae; p. 234, fig. 68.

Usinger and Matsuda mentioned in the generic description of *Neophloeobia* that the eyes are small; in *N. montrouzieri* they are slightly stylate.

1 ♀; Queensland, Mt. Tambourine—A. M. Lea coll.

2. **Neophloeobia tuberculata** n. sp.

Fig. 7-8

Male. Elongate ovate; opaque, but with shiny yellow brown, round callous spots, and shiny, red brown, tubercles of different size, similar to those on *Aegisocoris tuberculatus* n. sp.

Head shorter than width through the eyes (36:41). Anterior process stout, with subparallel sides, very slightly widening toward the tip, and deeply notched in front, reaching a little beyond the tip of antennal segment I; genae longer than clypeus and contiguous. Antenniferous tubercles strong, blunt, divaricating, reaching to the middle of antennal segment I. Eyes globose, salient, slightly stylate. Postocular tubercles dentiform, acute, directed obliquely backward, reaching to outer border of eyes. Antennae slender; segment I robust, clavate; II and III tapering toward the base, much more slender; IV pyriform. Proportions of antennal segments, I to IV, are: 12.5:9:12:11. The rostrum reaches slightly over the base of a deep rostral groove, the latter is open posteriorly.

Pronotum very short and wide (15:56); collar thin, but distinct; fore borders straight, slightly receding posteriorad; antero-lateral angles produced into small, rounded lobes, placed obliquely; postero-lateral angles bearing two (1 + 1) small tubercles. Lateral borders between lobes and tubercles short, and deeply incised. Hind border convex in the middle, sinuate laterally. Disc depressed medially, and provided with eight (4 + 4) low, longitudinal ridges, diminishing from inner ones to outer ones.

Mesonotum wider than pronotum (60:56), semifused in the middle with metanotum, but the suture is still discernible. It is raised medially, and provided with a yellow brown, glabrous median line, prolonged posteriorly over the metanotum and tergum I. Laterad of median ridge are placed two (1 + 1) large, round, yellow brown, callous spots. In the middle of each side disc is raised again but depressed near lateral borders.

Metanotum as wide as mesonotum (60:60), raised medially, and in the middle of each side, and fused posteriorly with tergum I. From lateral borders it is separated by the forwardly produced connexivum II.

Hemelytra reduced to very small, bean-shaped pads, just behind which are seen the apexes of metathoracic scent gland canals.

Abdomen slightly longer than maximal width across segment V (82:80). Tergum I raised medially, and sloping laterally. It is separated from the central dorsal plate by a distinct sulcus. Central dorsal plate consists of terga II to VI, which are fused together. Disc raised medially, and sloping laterally; the highest point being on tergum V. Scars of dorsal scent glands placed between terga III and IV. Disc covered with an irregular pattern of shiny, round tubercles, sometimes forming rows. A series of yellow brown, round, callous spots are placed in four rows with following formula: tergum II: – – – –; III: 1 – – 1; IV: 1 1 1 1; V: – 1 1 –, and VI: – 1 1 –. Tergum VII is raised in the middle posteriorly for the reception of the hypopygium; the latter is cordate, with a low, large, triangular ridge on the upper surface. Paratergites small, clavate, reaching slightly beyond the middle of hypopygium. Spiracles II to VII ventral, placed far from border; VIII lateral and visible from above.

Legs unarmed; arolia absent.

Colour: Dark brown, with yellow brown, round, callous spots, and red brown, shiny tubercles; legs, antennae, and rostrum yellow brown, partially infuscate.

Total length 6.16 mm.; width of pronotum, 2.24 mm.; width of abdomen, 3.20 mm.

Holotype: ♂, Queensland, Cairns district—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

N. tuberculata n. sp. stands a little apart from other two species of the genus, particularly in that the round, shiny tubercles (similar as those on *Aegisocoris*) are not found in other species, but the topography of the pronotum is similar to other species of *Neophloeobia*. On the other hand the topography of the abdomen is so different from that of *Aegisocoris* that *N. tuberculata* cannot be congeneric with the former, and it is best to place it in *Neophloeobia*.

All the genera from *Chelonoderus* to *Neophloeobia* form a very distinct group of Australian apterous or micropterous genera, and with all their apparent diversity in topography of their bodies they nevertheless have a few important characters in common, particularly the shape of the head, position of spiracles, and in that all segments

of the connexiva are clearly separated from each other. All these genera save *Drakiessa* have pronotum depressed, or sulcate on median line.

Gen. **Rossius** Usinger and Matsuda, 1959

Rossius was established on the base of a single species from New Guinea, *Crimia polyacantha* Walker, 1873, previously attributed to the genus *Barcinus* Stål, but in reality more related to *Artabanus* Stål, as Usinger and Matsuda have stated (1959: 260).

1. **Rossius polyacanthus** (Walker)

Fig. 9

Crimia polyacantha Walker, 1873, Cat. Hem. Het. Brit. Mus., **7**: 17.

Barcinus polyacanthus Distant, 1902, Ann. Mag. Nat. Hist., (7) **9**: 359.

Rossius polyacanthus Usinger and Matsuda, 1959, The Class. Aradidae, p. 258, fig. 75.

Rossius polyacanthus (Walker) is a rather variable species referring to the length of genae and the shape of lateral lobes of abdominal segments VI and VII. Genae in some specimens are distinctly shorter than antennal segment I, in other reaching to, or even produced beyond the apex of the latter. Lateral lobes of segments VI and VII vary in width, and even in shape: sometimes they are similar, sometimes those of segment VI are narrower than VII, some of them are obliquely truncate, and other not.

1 ♂ and 1 ♀, New Guinea, Wareo, Finsch Haven—Rev. L. Wagner coll.

Gen. **Artabanus** Stål, 1865

Artabanus is an Oriental genus penetrating into Oceania and Australia. It is rather heterogenous, but all species have in common a peculiar stridulatory apparatus.

In 1873 Stål described *Artabanus sinuatus* from New Guinea. In the same year Walker described *Crimia doreica* also from New Guinea, which later was transferred by Distant to *Artabanus* (1902: 359). The description of Stål is pretty good for his time, so that it was not difficult to identify this species among specimens from New Guinea. The description of Walker is bad, but I have had an opportunity to examine his type at the British Museum (N.H.), and it resulted to be conspecific with *A. sinuatus* Stål, so that these two species should be synonymized, but I was not able to determine which name has priority.

1. **Artabanus bilobiceps** (Lethierry)

Brachyrrhynchus bilobiceps Lethierry, 1888, Ann. Mus. Civ. Stor. Nat., Genova, **26**: 464.

Artabanus atkinsoni Bergroth, 1889, Ann. Mus. Civ. Stor. Nat., Genova, **27**: 724, tab. 12, fig. 5.

Artabanus bilobiceps Bergroth, 1892, Ann. Mus. Civ. Stor. Nat., Genova, **32**: 715.

1 ♂, Java, Buitenzorg—A. M. Lea coll.

1a. **Artabanus bilobiceps papuasicus** n. subsp.

Similar to *A. bilobiceps* from Java, but lateral teeth on the pronotum reduced to half the size of those of *bilobiceps s. str.* Other characters as in parent species.

Holotype ♂, allotype ♀, and 3 ♀, paratypes—New Guinea, N.E. Papua, Mt. Lamington, 1,300-1,500 feet—C. T. McNamara coll.; deposited in the South Australian Museum, Adelaide, and (1 paratype) in author's collection.

2. **Artabanus truncatus** n. sp.

Female. Elongate ovate; partially covered with short, curled, ferruginous hairs.

Related to *Artabanus lativentris* Esaki and Matsuda, 1951, from which it differs by: antero-lateral angles of pronotum obliquely truncate, without any teeth and forming a trapezoidal lobe; by different proportions of antennal segments, segment III being relatively shorter, and by the colour, which is uniformly dark brown; bases of antennal segment, and legs, reddish brown; rostrum and tarsi yellow brown.

Measurements: head almost as long as width through the eyes (33:32); proportions of antennal segments, I to IV, are: 17:12:22:12; pronotum half as long as maximal width (34:72); scutellum shorter than width at the base (30:47); abdomen as long as maximal width across segment IV (89:88).

Total length, 7.48 mm.; width of pronotum, 2.88 mm.; width of abdomen, 3.52 mm.

Holotype: ♀, New Guinea, Finsch Haven, Wareo—Rev. L. Wagner coll.; deposited in the South Australian Museum, Adelaide .

Paratype: 1 ♀, collected with holotype; in author's collection.

3. **Artabanus tuberculatus** n. sp.

Female. General aspect of *A. geniculatus* Stål, 1870, but the head is shorter, as long as width through the eyes; anterior process with

contiguous juga, reaches slightly beyond the middle of antennal segment I. Vertex raised, granulate, flanked by two (1 + 1) oblique, diverging posteriorly, deep furrows. Pronotum and scutellum similar to *A. geniculatus*. Baso-lateral border of corium carinate, and sinuate. Abdomen longer than maximal width (as long as wide in *A. geniculatus*). Posterior borders and postero-interior angles of connexiva are both inflated. Tergum VII semicircularly depressed in the middle, and with a semicircular ridge around depression (with two lateral humps and median depression in *A. geniculatus*). On ventral side are dispersed, round, shiny, tubercles of different sizes: a row along rostral groove, and a few behind eyes; on meso- and metapleura, and acetabula; a row of finer tubercles on hind borders of sterna IV and V, and a group on sterna VI laterally. These tubercles are absent in other species.

Measurements: head, 31:30; proportions of antennal segments: 15:10:18:12.5; pronotum, 30:67; scutellum, 30:35; abdomen, 80:77.

Colour: dark reddish brown; antennal segment I at base, III and IV entirely, and trochanters, are lighter; rostrum and tarsi yellow.

Total length, 6.64 mm.; width of pronotum, 2.68 mm.; width of abdomen, 3.08 mm.

Holotype: ♀, Malay Peninsula, Gap (Fraser Hill)—A. M. Lea and wife coll.; deposited in the South Australian Museum, Adelaide.

4. **Artabanus mcfarlandi** n. sp.
Fig. 16

Male. Elongate ovate; partially covered with short, curled yellow brown hairs.

Head as long as width through the eyes (♂—17:17, ♀—18:18). Anterior process long and slender, slightly constricted in the middle, and deeply incised in front, genae much longer than clypeus and rounded apically, reaching slightly beyond the tip of antennal segment I. Antenniferous tubercles dentiform, strong, divaricating, reaching to the middle of antennal segment I. Eyes globose, stylate. Post-ocular borders firstly sinuate, then slightly convex. Vertex with two (1 + 1) curved carinae. Antennae slender, one and a half times as long as head (♂—25:17, ♀—25:18). Proportions of antennal segments, I to IV, are: ♂—7:5:8:5, ♀—7:5:8:5. Rostrum reaches to the base of head; rostral groove deep, open posteriorly; rostral atrium narrowly open.

Pronotum much shorter than maximal width (♂—13:32, ♀—13:34). Collar sinuate in front, distinctly separated from disc. Antero-lateral angles expanded into large, subtriangular lobes, produced forward

beyond collar, and sideways. Lateral notch deep, rounded. Lateral borders of hind lobe convex, rounded; hind border three times sinuate: in the middle, and laterally. Interlobal depression deep. Fore lobe with four (2 + 2) longitudinal ridges, and with a median depression; hind lobe granulate.

Scutellum slightly shorter than width at the base (♂—14:15, ♀—14:18); all borders carinate; lateral borders straight, slightly sinuate before the tip; median carina high and slender, bifurcate at base, and produced forward, slightly overlapping pronotum. Disc transversely, roughly rugose.

Hemelytra reach to the middle of tergum VII (♂), or to posterior border of tergum VI (♀). Baso-lateral border of corium slightly expanded, angularly produced anteriorly, straight posteriorly; apical angle of corium rounded; apical border straight exteriorly, deeply, and roundly, excised interiorly.

Abdomen slightly longer than maximal width across segment IV in male (39:37), slightly shorter than maximal width across segment V in female (42:45). Abdomen slightly widening posteriorly in male, ovate in female. Connexivum wide and horizontal; PE-angles angularly protruding from II to V, rounded in VI, produced as small rounded lobes directed backward in VII. Tergum VII raised posteriorly, and depressed along hind border, which is raised. Paratergites reach to ¾ of hypopygium; the latter transverse, much shorter than maximal width (5:13), with a short median ridge, rounded apically, and surrounded by a sulcus. In the female, tergum VII raised laterally, and depressed in the middle; paratergites large, rounded, produced as far as small segment IX; the latter incised posteriorly. Spiracles II to VI ventral, VII and VIII lateral and visible from above. Stridulatory apparatus consists of a high, sharp carina running obliquely from a hind portion of sternum III across sternum IV, and of sharp, setigerous granules on hind femora.

Colour: testaceous; hind half of head, fore lobe of pronotum in the middle, disc of scutellum, tip of corium, membrane, large spots on connexiva III and IV, and small on V and VI, tergum VII, hypopygium, and most of ventral surface, and legs, are black, or infuscate.

Total length: ♂—8.5, ♀—9.1 mm.; width of pronotum: ♂—3.2, ♀—3.4 mm.; width of abdomen: ♂—3.7, ♀—4.5 mm.

Holotype: ♂, Fiji, Viti Levu, Suva—A. N. McFarland coll. 6th Nov. 1964; under loose bark of decaying logs, in an old woodpile on the ground; deposited in the South Australian Museum, Adelaide.

Allotype: ♀, collected with holotype; in the same collection.

Paratypes: 6 ♂, 3 ♀, and 10 nymphs of different instars, all collected with holo- and allotype; in the same and author's collection.

It is a pleasure to dedicate this species to its collector, Mr. A. N. McFarland.

Artabanus mcfarlandi n. sp. belongs to the "*doreicus* group", and is related to *A. doreicus* (Walker), 1873 (or *A. sinuatus* Stål, 1873, whichever of these names proves to have priority), but it is smaller, and the antero-lateral lobes of the pronotum are differently shaped; abdomen in males with straight borders, not constricted at segment V.

5. **Artabanus doreicus** (Walker)

Crimia doreica Walker, 1873, Cat. Hem. Het. Brit. Mus., **7**: 17.
Artabanus sinuatus Stål, 1873, Enum. Hem., **3**: 141.
Artabanus doreicus Distant, 1902, Ann. Mag. Nat. Hist., (7) **9**: 359.

3 ♂ and 1 ♀, New Guinea, N. E. Papua, Mt. Lamington—C. T. McNamara coll.; 1 ♂, New Guinea, Finsch Haven, Wareo—Rev. L. Wagner coll.

Gen. **Ctenoneurus** Bergroth, 1887

Ctenoneurus Bergroth is curiously distributed in two separate areas: the first extends from New Zealand and Australia northward across New Guinea to Fiji and New Caledonia, the second area covers Central Africa (Ruanda, Congo, Gabon) to São Tomé Island in the Gulf of Guinea and Madagascar. One of the main characters in this genus is a transverse carina near the fore border of sterna IV, V and VI. A new species from New Guinea described here has all the other characters of *Ctenoneurus* save this one, it has no carina on sterna IV, V and VI. It has a convex head, with a long and narrow anterior process reaching to the tip of antennal segment I. Also the general aspect of the body, rather convex on the ventral side, with small spines at basal angles of scutellum and most of all the spiracles, large and placed close to the border, are characters of *Ctenoneurus*, and not of *Mezira* A.S., I have deemed it better to place it in *Ctenoneurus*.

1. **Ctenoneurus bergrothianus** Kirkaldy

Ctenoneurus bergrothianus Kirkaldy, 1908, Proc. Linn. Soc., Sydney, **33**: 350.

2 ♂ and 2 ♀, Fiji, Viti Levu—A. M. Lea coll.

2. **Ctenoneurus halaszfyi** Kormilev

Ctenoneurus halaszfyi Kormilev, 1958, Jour. N.Y. Ent. Soc., **66**: 92.

4 ♂ and 3 ♀, New Guinea, Finsch Haven, Wareo—Rev. L. Wagner coll.

3. **Ctenoneurus aberrans** n. sp.

Fig. 10-11

Female. Elongate ovate, rather convex; finely granulate.

Head as long as width through the eyes (27.5:27); anterior process long, with parallel sides and slightly notched in front, reaching to the tip of antennal segment I. Antenniferous tubercles short, acute, convex exteriorly, reaching to ¼ of antennal segment I. Eyes semiglobose, protruding. Postocular tubercles form an obtuse angle and do not reach to outer border of eyes. Vertex convex, granulate; mesad of eyes are placed two (1 + 1) ovate callosities. Antennae strong; proportions of antennal segments, I to IV, are: 10:9:10:12. Rostrum reaches to hind border of head; rostral atrium closed; rostral groove deep, open posteriorly.

Pronotum half as long as maximal width (25:52); collar slightly sinuate in front; antero-lateral angles rounded, produced forward as far as collar. Lateral borders parallel at humeri, convergent anteriorly. Hind border broadly sinuate. Depression between the lobes weak. Fore lobe with two (1 + 1) low, round elevations, and laterad of them with two (1 + 1) longitudinal, low ridges, which are semiobliterated. Hind disc granulate.

Scutellum shorter than basal width (25:35); small spines at basal angles of scutellum present; lateral borders carinate and slightly sinuate; tip angularly rounded; median carina low, tapering backward; disc irregularly, finely rugose.

Hemelytra reach to hind border of tergum VI; apical angle of corium acute; apical border straight, but slightly receding and rounded interiorly. Membrane with anastomosing veins.

Abdomen longer than maximal width across segment IV (67:60). Lateral borders subparallel, barely convex; connexivum moderately wide, sloping inwardly; midlateral area indistinctly separated from connexivum. PE-angles not protruding. Tergum VII weakly raised, and slightly depressed in the middle. Paratergites conical, divergent, produced beyond tip of small segment IX, which is rounded posteriorly. Spiracles II to VI ventral, large, placed near the border; VII sublateral but visible from above; VIII terminal. Sternum VI once sinuate in the middle; sterna IV to VI without transverse carina anteriorly.

Legs unarmed; trochanters free; arolia thin and long.

Colour: sepia-brown; antennae and tibiae lighter, brown; rostrum and tarsi yellow brown.

Total length, 5.70 mm.; width of pronotum, 2.08 mm.; width of abdomen, 2.40 mm.

Holotype: ♀, New Guinea, N.E. Papua, Mt. Lamington—C. T. McNamara coll.; deposited in the South Australian Museum, Adelaide.

Ctenoneurus aberrans n. sp. resembles *C. australis* Kormilev, 1965, but is wider, scutellum with almost straight sides; corium not sinuate interiorly, and carinae on sterna IV to VI absent.

Gen. **Neuroctenus** Fieber, 1861

Neuroctenus is an almost cosmopolitan genus but does not reach Europe, or other colder areas. In the South Pacific Islands and New Zealand it is replaced by *Ctenoneurus*.

1. **Neuroctenus hanschini** Kormilev

Neuroctenus hanschini Kormilev, 1953, Verh. Naturf. Ges. Basel, **64**: 342.

Distributed in Australia: Northern Territory and Queensland.

Various specimens from Port Darwin, Batchelor, and Stapleton, in the Northern Territory, and from Somerset, and Bluff, in Queensland.

2. **Neuroctenus majusculus** Bergroth

Neuroctenus majusculus Bergroth, 1887, Ofv. Finska Vet. Soc.-Förh., **29**: 181.

1 ♂ and 2 ♀, West Australia, Warren R.—W. D. Dodd coll.

3. **Neuroctenus proximus** (Walker)

Mezira proxima Walker, 1873, Cat. Hem. Het. Brit. Mus., **7**: 28.

Neuroctenus proximus Bergroth, 1887, Ofv. Finska Vet.-Soc. Förh., **29**: 187.

1 ♀, Tasmania, W. Tamar.

4. **Neuroctenus serrulatus** Stål

Neuroctenus serrulatus Stål, 1870, Ofv. Vet. Ak. Förh., **27**: 674.

2 ♀, Queensland, Somerset—C. T. McNamara coll.; 2 ♂ and 1 ♀, Queensland, Kuranda—F. P. Dodd coll.; 2 ♂ and 2 ♀, New Guinea, Papua, Misima I.—H. K. Bartlett coll.; 3 ♀, Malaya, Singapore—A. M. Lea and C. T. McNamara coll.; 1 ♂ and 3 ♀, Malay Peninsula, Gap (Fraser Hill)—A. M. Lea and wife coll.

5. **Neuroctenus meziroides** Kormilev

Neuroctenus meziroides Kormilev, 1958, Jour. N.Y. Ent. Soc., **66**: 94.

3 ♂ 3 ♀, New Guinea, Port Moresby, Bisiatabu—W. N. Lock coll.; 2 ♀, New Guinea, Finsch Haven, Wareo—Rev. L. Wagner coll.; 5 ♂ and 5 ♀, New Guinea, Papua, Misima I.—Rev. H. K. Bartlett coll.

6. **Neuroctenus nitidulus** Bergroth

Neuroctenus nitidulus Bergroth, 1887, Ofv. Finska Vet.-Soc. Förh., **29**: 177.

8 ♂ and 2 ♀, Malay Peninsula, Gap (Fraser Hill)—A. M. Lea and wife coll.; 3 ♂ and 4 ♀, New Guinea, Finsch Haven, Wareo—Rev. L. Wagner coll.; 1 ♂, New Guinea, Papua, Mt. Lamington—C. T. McNamara coll.

7. **Neuroctenus vicinus** Signoret

Neuroctenus vicinus Signoret, 1880, Ann. Mus. Civ. Stor. Nat., Genova, **15**: 542.

4 ♂ and 4 ♀, New Guinea, N.E. Papua, Mt. Lamington—C. T. McNamara coll.

Gen. **Barcinus** Stål, 1873

1. **Barcinus truncatus** Kormilev

Barcinus truncatus Kormilev, 1955, Ann. Mag. Nat. Hist., (12) **8**: 196.

2 ♀, New Guinea, N.E. Papua, Mt. Lamington—C. T. McNamara coll.; 2 ♂, New Guinea, Finsch Haven, Wareo—Rev. L. Wagner coll.

Gen. **Crimia** Amyot and Serville, 1843

1. **Crimia tuberculata** Amyot and Serville

Crimia tuberculata Amyot and Serville, 1843, Hemipt., p. 305.

1 ♂, Malay Peninsula, Gap (Fraser Hill)—A. M. Lea and wife coll.

Gen. **Pictinellus** Usinger and Matsuda, 1959

Usinger and Matsuda listed only four species of *Pictinellus,* though they mentioned that they have seen up to 15 species (1959: 290).

In 1959, almost simultaneously with the appearance of the Classification of Aradidae by Usinger and Matsuda, Kiritshenko published a new species from Japan, which he put into a new subgenus of *Mezira* A.S., naming it *Mezira* (*Mezirella*) *infantulus* Kiritshenko, 1959. From the description and a very good drawing, I could see that it was not a subgenus of *Mezira,* but belonged to one of the new genera of Usinger and Matsuda, so I transferred it tentatively to *Pictinellus.*

Later I got, by the kind offices of Dr. I. M. Kerzhner, a paratype of *Mezira* (*Mezirella*) *infantulus,* and can now see that it belongs not to *Pictinellus,* but to a related genus, *Glochocoris* Usinger and Matsuda, 1959. The new combination is therefore *Glochocoris infantulus* (Kiritshenko), 1959.

In this lot were a few species of *Pictinellus* from Malay Peninsula, Fiji, and New Guinea. Below is a key to the *Pictinellus* species from Fiji.

Key for species of *Pictinellus* Usinger and Matsuda from Fiji.

1. Head longer than width through the eyes 2
   Head as long, or shorter, than width through the eyes 3
2. Smaller species, female less than 4.25 mm., with segment IX conical; lateral borders of pronotum distinctly sinuate *P. elongatus* n. sp., Viti Levu

   Larger species, female over 4.50 mm., with segment IX rectangular, truncate posteriorly; lateral borders of pronotum almost straight .. .. *P. longiceps* n. sp., Viti Levu
3. Lateral borders of pronotum distinctly sinuate 4
   Lateral borders of pronotum almost straight, barely sinuate .. .. *P. moturikiensis* n. sp., Moturiki, Viti Levu
4. Spiracles VII sublateral, and slightly visible from above; antennal segment II narrowly fusiform (4.5:2) .. .. .. *P. leai* n. sp., Viti Levu
   Spiracles VII sublateral, but not visible from above; antennal segment II widely fusiform (3.5:2) .. .. *P. fungicola* (Kirkaldy), 1908, Viti Levu

1. **Pictinellus papuasicus** n. sp.

Fig. 12-13

Male. Elongate, subparallel; hind lobe of pronotum finely granulate.

Head short, almost as long as width through the eyes. Anterior process of the head strongly constricted in the middle, slightly notched in front, reaches to the middle of antennal segment I. Antenniferous tubercles transversely truncate in front, slightly convex exteriorly.

Anterior angles of pronotum produced forward, acute; lateral borders sinuate. Hypopygium cordate, with a high, triangular ridge, reaching almost to the tip of hypopygium; paratergites long, strongly dilated and incised, reaching to the tip of hypopygium, with spiracle placed laterally.

Measurements: head as long as maximal width (12:12.5); proportions of antennal segments, I to IV, are: 5:2.5:6:5.5; pronotum less than half as long as maximal width (11:24); scutellum almost as long as basal width (12:13); abdomen much longer than maximal width (43:27); hypopygium almost as long as wide (8:9). Spiracles: II lateral and visible from above, III to VI ventral, placed far from the border; VII sublateral, but not visible from above; VIII lateral and visible.

Colour: testaceous; membrane blackish, white at the base.

Total length, 3.28 mm.; width of pronotum, 0.96 mm.; width of abdomen, 1.08 mm.

Holotype: ♂, New Guinea, N.E. Papua, Mt. Lamington—C. T. McNamara coll.; deposited in the South Australian Museum, Adelaide.

Pictinellus papuasicus is related to *P. fungicola* (Kirkaldy), 1908, from which it differs by the different shape of its hypopygium and paratergites, and by a lighter colouration.

2. **Pictinellus fungicola** (Kirkaldy)

Ctenoneurus fungicola Kirkaldy, 1908, Proc. Linn. Soc., Sydney, **33**: 352.

Pictinellus fungicola Usinger and Matsuda, 1959, Class. Aradidae; p. 269.

As the description of Kirkaldy dealt mostly with the colouration, I am giving a short redescription.

Head as long as width through the eyes (♂—12:12, ♀—12.5:12.5); anterior process slightly constricted in the middle, dilated and incised in front, reaches to the middle of antennal segment I. Antenniferous tubercles obliquely truncate in front. Anterior angles of pronotum produced forward, acute; lateral borders sinuate. Hypopygium cordate, short, median ridge thin and lower than in preceding species. Paratergites simple, clavate, not incised. In the female, paratergites large rounded, reach to $\frac{1}{3}$ of a trapezoidal segment IX. Spiracles: II lateral and visible from above, III to VI ventral, placed far from the border; VII sublateral, but not visible from above; VIII lateral and visible. Antennal segment II wide (3.5:2).

Proportions of antennal segments, I to IV, are: ♂—6:4:6:5.5, ♀—6.5:3.5:6:6. Pronotum half as long as maximal width (♂—12:24, ♀—12:26); scutellum almost as long as basal width (♂—12:13, ♀—12.5:14); abdomen longer than maximal width (♂—40:25.5, ♀—46:28).

Colour: ferrugineous; connexivum, rostrum, tarsi and ventral side lighter.

Total length: ♂—3.12, ♀—3.48 mm.; width of pronotum: ♂—0.96, ♀—1.04 mm.; width of abdomen: ♂—1.02, ♀—1.12 mm.

1 ♂ and 5 ♀, Fiji, Viti Levu—A. M. Lea coll.

3. **Pictinellus leai** n. sp.

Fig. 14-15

Female. Elongate ovate, widening posteriorly; finely granulate.

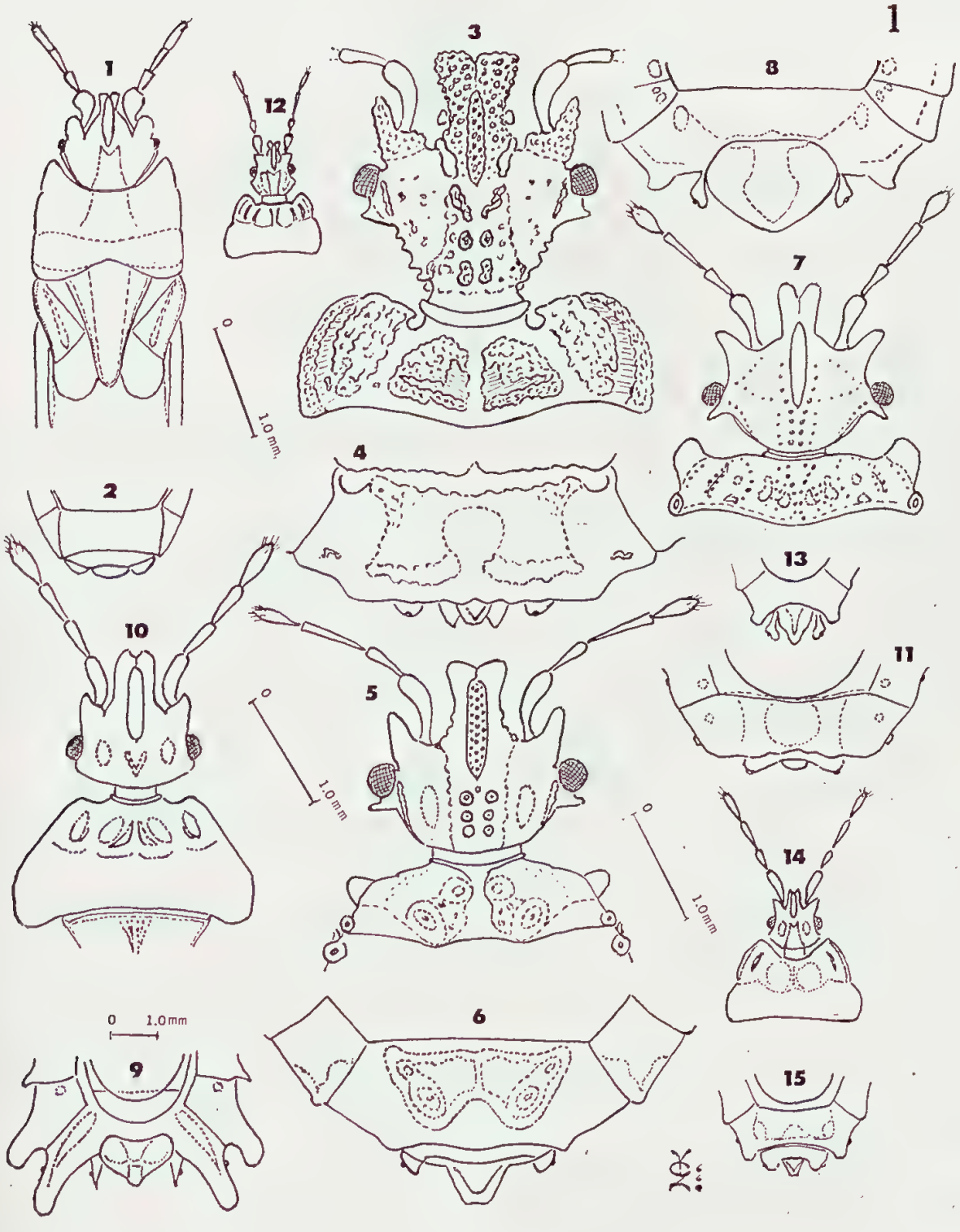
Head as long as width through the eyes; anterior process tapering forward, incised in front, reaching to ⅓ of antennal segment I; antenniferous tubercles obliquely truncate in front, divergent. Anterior angles of pronotum produced forward, acute; lateral borders sinuate; abdomen with regularly rounded borders. Paratergites large, rounded, reaching to the middle of segment IX; the latter trapezoidal, slightly convex apically. Spiracles: II lateral and visible from above, III to VI ventral, placed far from the border; VII sublateral and slightly visible from above; VIII lateral. Antennal segment II narrower than in *P. fungicola* (4.5:2).

Measurement: head, 14:14; proportions of antennal segments, I to IV, are: 7.5:4.5:8:6.5; pronotum, 13:28; scutellum, 14:15; abdomen, 55:35.

Colour: ferrugineous; membrane blackish, white at the base; tarsi yellow.

LEGEND TO FIGURES

Fig. 1. Anterior half of *Aspisocoris termitophilus* n. sp.
Fig. 2. Termination of abdomen of *Aspisocoris termitophilus* n. sp.
Fig. 3. Head and pronotum of *Argocoris grossi* n. sp.
Fig. 4. Termination of abdomen of *Argocoris grossi* n. sp.
Fig. 5. Head and pronotum of *Aegisocoris granulatus* n. sp.
Fig. 6. Termination of abdomen of *Aegisocoris granulatus* n. sp.
Fig. 7. Head and pronotum of *Neophloeobia tuberculata* n. sp.
Fig. 8. Termination of abdomen of *Neophloeobia tuberculata* n. sp.
Fig. 9. Termination of abdomen of *Rossius wagneri* n. sp.
Fig. 10. Head and pronotum of *Ctenoneurus aberrans* n. sp.
Fig. 11. Termination of abdomen of *Ctenoneurus aberrans* n. sp.
Fig. 12. Head and pronotum of *Pictinellus papuasicus* n. sp.
Fig. 13. Termination of abdomen of *Pictinellus papuasicus* n. sp.
Fig. 14. Head and pronotum of *Pictinellus leai* n. sp.
Fig. 15. Termination of abdomen of *Pictinellus leai* n. sp.


1
1
3
8
12
7
1.0 mm
4
2
13
10
11
5
1.0mm
1.0mm
14
0 1.0mm
6
9
15

Total length, 3.88 mm.; width of pronotum, 1.12 mm.; width of abdomen, 1.40 mm.

Holotype: ♀, Fiji, Viti Levu—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Paratypes: 4 ♀, collected with holotype; in the same, and author's collection.

This species is dedicated to Mr. A. M. Lea, who collected so many new species represented in this lot.

4. **Pictinellus moturikiensis** n. sp.

Fig. 17-18

Female. Elongate, with subparallel sides; finely punctured.

Head slightly shorter than width through the eyes; anterior process slightly constricted in the middle, dilated and incised in front, reaches $\frac{2}{5}$ of antennal segment I; antenniferous tubercles obliquely truncate in front. Anterior angles of pronotum produced forward, acute; lateral borders straight, or barely sinuate. The body is wider than in *P. fungicola*. Spiracles: II lateral and visible from above, III to VI ventral, placed far from the border; VII sublateral, but not visible from above; VIII lateral. Paratergites large, rounded, reaching to $\frac{4}{5}$ of a conical, rounded posteriorly segment IX. Hypopygium of the male small, cordate; paratergites very small, clavate, reaching to the middle of hypopygium.

Measurements: head almost as long as width through the eyes (♀—13:15, ♂—12:13); proportions of antennal segments, I to IV, are: ♀—8:5:7:7, ♂—7:4.5:7:7; pronotum short and wide (♀—13:31, ♂—12:27.5); scutellum shorter than basal width (♀—15:17.5, ♂—13:15); abdomen longer than maximal width (♀—53:35, ♂—44:30); hypopygium 6:7.5.

Colour: ferrugineous; membrane white, hyaline, rarely slightly infuscate; tarsi yellow brown.

Total length: ♀—3.92 to 4.00, ♂—3.92 mm.; width of pronotum: ♀—1.24 to 1.26, ♂—1.10 mm.; width of abdomen: ♀—1.40, ♂—1.20 mm.

Holotype: ♀, Fiji, Moturiki—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Allotype: ♂, Fiji, Viti Levu—A. M. Lea coll.; in the same collection.

Paratypes: 3 ♀, collected with holotype, and 2 ♂, collected with allotype; in the same, and author's collection.

Pictinellus moturikiensis n. sp. is related to *P. fungicola* (Kirkaldy), 1908, but is slightly larger, and distinctly wider; lateral borders of pronotum straight, or almost straight, and anterior process of the head relatively shorter.

5. **Pictinellus elongatus** n. sp.

Fig. 19-20

Female. Elongate, with subparallel sides; granulation distinct.

Head longer than width through the eyes; anterior process with subparallel sides, incised in front, reaching to $\frac{2}{5}$ of antennal segment I; antenniferous tubercles dentiform, subparallel exteriorly. Anterior angles of pronotum produced forward, but blunt apically; lateral borders distinctly sinuate. Segment IX conical, rounded apically; paratergites large, rounded, reaching almost to the tip of IX. Hypopygium of the male small, cordate; paratergites clavate, reaching slightly beyond the middle of hypopygium. Spiracles: II lateral and visible from above, III to VI ventral; VII sublateral, but not visible from above; VIII lateral and visible.

Measurements: head: ♀—15:12, ♂—13:11; proportions of antennal segments, I to IV, are: ♀—8.5:5:10:8, ♂—7.5:5:8:7.5; pronotum: ♀—14.5:26, ♂—13:23.5; scutellum: ♀—15:17, ♂—12:13; abdomen: ♀—57:32, ♂—47.5:29; hypopygium: 6.5:6.5.

Colour: light ferrugineous; membrane white, hyaline.

Total length: ♀—4.12, ♂—3.5 mm.; width of pronotum: ♀—1.04, ♂—0.94 mm.; width of abdomen: ♀—1.28, ♂—1.16 mm.

Holotype: ♀, Fiji, Viti Levu—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Allotype: ♂, collected with the holotype; in the same collection.

Paratype: 1 ♀, collected with holo- and allotype; in author's collection.

6. **Pictinellus longiceps** n. sp.

Fig. 21-22

Female. Elongate ovate, with indistinct, very fine granulation.

Head longer than width through the eyes; anterior process with parallel sides, barely incised in front, reaches to $\frac{1}{3}$ of antennal segment I; antenniferous tubercles dentiform, acute, subparallel exteriorly. Anterior angles of pronotum produced forward, acute with blunt tip; lateral borders almost straight, barely sinuate. Segment IX rectangular, truncate posteriorly; paratergites large, tapering and

rounded, sinuate outside, reaching to the tip of IX. Spiracles: II lateral and visible from above, III to VI ventral; VII sublateral, but not visible from above; VIII lateral and visible.

Measurements: head, 17:13; proportions of antennal segments, I to IV, are: 10:6:12.5:8; pronotum 18:30; scutellum 15:17; abdomen 68:38.5.

Colour: dark ochraceous; head, antennal segment I, pronotum, with exception of lateral borders, scutellum, and corium, infuscate; antennal segments II to IV pale testaceous; connexivum ochraceous.

Total length, 4.72 mm.; width of pronotum, 1.20 mm.; width of abdomen, 1.54 mm.

Holotype: ♀, Fiji, Viti Levu—A. M. Lea coll.; deposited in the South Australian Museum, Adelaide.

Pictinellus longiceps n. sp. is related to *P. elongatus* n. sp., both forming together a separate group with a long head; their differences are indicated in the key.

7. **Pictinellus malayensis** n. sp.

Fig. 23-25

Female. Elongate, with parallel sides, roughly granulate.

Head as long as, or slightly shorter than width through the eyes; anterior process thin, with parallel sides, slightly incised in front, reaching slightly beyond the middle of antennal segment I; antenniferous tubercles small, dentiform, exteriorly parallel, or slightly divaricating. Anterior angles of pronotum slightly expanded, rounded; lateral borders parallel at humeri, very slightly sinuate in front. Segment IX trapezoidal, tricuspidate, apically; paratergites short, rounded, reaching to $\frac{1}{4}$ of IX. Hypopygium of the male large, conical, inflated on the disc; paratergites very small, clavate, reach to $\frac{1}{3}$ of hypopygium. Spiracles: II lateral and visible from above, III to VI ventral; VII sublateral, but not visible from above; VIII lateral and visible.

Measurements: head: ♀—15:16, ♂—15:15; proportions of antennal segments, I to IV, are: ♀—7:5:7.5:7.5, ♂—7:4.5:-:- (two apical segments missing); pronotum: ♀—16:35, ♂—15:32; scutellum: ♀—16:17, ♂—15:15; abdomen: ♀—66:38, ♂—62:36; hypopygium: 14:14.

Colour: dark ferrugineous; connexivum pale ferrugineous; membrane infuscate, white at the base; tarsi yellow.

Total length: ♀—4.64, ♂—4.40 mm.; width of pronotum: ♀—1.40, ♂—1.30 mm.; width of abdomen: ♀—1.52, ♂—1.44 mm.

Holotype: ♀, Malay Peninsula, Gap (Fraser Hill)—A. M. Lea and wife coll.; deposited in the South Australian Museum, Adelaide.

Allotype: ♂, collected with holotype; in the same collection.

Paratypes: 3 ♀, collected with holo- and allotype; in the same, and author's collection.

Pictinellus malayensis n. sp. differs from the other species by having rounded anterior angles to the pronotum, which are barely produced beyond the fore border of the collar.

Gen. **Glochocoris** Usinger and Matsuda, 1959

Glochocoris is a small genus, related to *Pictinellus,* and distributed in the Oriental Region, Micronesia, New Guinea, and Australia; one species has been recorded as far west as the Seychelles.

1. **Glochocoris monteithi** Kormilev

Glochocoris monteithi Kormilev, 1967, Proc. R. Soc. Qd., **79**: 77.

2 ♀, Queensland, Mt. Tambourine—A. M. Lea coll.

Gen. **Arictus** Stål, 1865

Arictus is distributed in the Oriental Region, Micronesia, New Caledonia, New Guinea, and Australia.

1. **Arictus izzardi** (Kormilev)

Mezira izzardi Kormilev, 1955, Rev. Ecuatoriana Ent. Par., **2**: 503.

Arictus izzardi Usinger and Matsuda, 1959, Class. Aradidae, p. 314.

1 ♂, Fiji, Viti Levu—A. M. Lea coll.

2. **Arictus beta** (Kormilev)

Mezira beta Kormilev, 1955, Rev. Ecuatoriana Ent. Par., **2**: 501.

Arictus beta Usinger and Matsuda, 1959, Class. Aradidae, p. 314.

1 ♂, New Guinea, Finsch Haven, Wareo—Rev. L. Wagner coll.

3. **Arictus lobuliventris** (Kormilev)

Mezira lobuliventris Kormilev, 1953, Verh. Naturf. Ges., Basel, **64**: 340.

Arictus lobuliventris Usinger and Matsuda, 1959, Class. Aradidae, p. 314.

4 ♂ and 6 ♀, from New Guinea (Mt. Lamington; Finsch Haven, Wareo; Torricelli Mts.; Mt. Gyrifrie, and Misima Island).

4. **Arictus thoracoceras** (Montrouzier)

Aradus thoracoceras Montrouzier, 1855, Ann. Soc. Phys., Lyon, (2) **7**: 107.

Arictus thoracoceras Stål, Öfv. Sv. Vet. Ak. Förh., **27**: 672.

Brachyrhynchus thoracoceras Bergroth, 1886, Verh. Bot. Zool. Ges., Wien, **36**: 59.

Mezira thoracocera Kormilev, 1953, Verh. Naturf. Ges., Basel, **64**: 340.

Arictus thoracoceras Usinger and Matsuda, 1959, Class. Aradidae, p. 314.

15 ♂ and 12 ♀, from New Guinea (Torricelli Mts.; Mt. Gyrifrie; Port Moresby; Finsch Haven, Wareo; Mt. Lamington, and Misima I.).

5. **Arictus monteithi** Kormilev

Arictus monteithi Kormilev, 1965, Proc. Roy. Soc. Queensland, **77**: 32.

10 ♂ and 9 ♀, Australia, Northern Territory, Queensland, and N.S.W. (Bathurst I.; Port Darwin; Howard R.; Bluff R.; Mackay; Groote Eyland; Magnetic I.; Bowen; Cairns Distr. and Dorrigo).

It is common in Queensland and the Northern Territory.

Gen. **Mezira** Amyot and Serville, 1843

A cosmopolitan genus, distributed all over the world, with the exception of the colder areas. In Europe and Siberia it is rather rare.

1. **Mezira australis** (Walker)

Crimia australis Walker, 1873, Cat. Hem. Het. Brit. Mus., **7**: 22.

Brachyrhynchus australis Distant, 1902, Ann. Mag. Nat. Hist., (7) **9**: 360.

Mezira australis Usinger and Matsuda, 1959, Class Aradidae, p. 379.

This species is distributed from the Northern Territory to South Australia, but I have never seen it in large series.

3 ♂ and 2 ♀, Northern Territory, Stapleton—G. F. Hill coll.; 4 ♂ and 1 ♀, Northern Territory—Tepper coll.; 1 ♀, Queensland, Bowen—A. Simson coll.; 1 ♀, N.S.W., Mullaley—F. E. Wilson coll.; 1 ♂ and 1 ♀, N.S.W., Gunnedah—F. E. Wilson coll.; 4 ♂, 1 ♀ and 7 nymphs, South Australia, Melrose—A. M. Lea coll.; 2 ♀, South Australia, Mt. Remarkable—F. E. Wilson coll.; 2 ♂, South Australia, Flinders Range, Parachilna—H. Hale coll.

2. **Mezira wilsoni** n. sp.

Male. Closely related to *Mezira australis* (Walker), 1873, and probably frequently confused with it in the past. The main difference is in the pronotum: in *M. australis* the antero-lateral angles are only slightly expanded, rounded, but do not reach to the fore border of the rather well developed collar; the four (2 + 2) longitudinal ridges

of the fore lobe are less developed, all four are the same height. In *M. wilsoni* n. sp. the antero-lateral angles are also rounded, but produced forward beyond the collar; the inner pair of the four ridges are much higher, and superimposed slightly over the collar. The other characters are as in *Mezira australis* (Walker).

Measurements: head shorter than width through the eyes (♂—26:30, ♀—27:32), or across postocular tubercles (♂—26:33, ♀—27:34). Proportions of antennal segments, I to IV, are: ♂—10:11:15:12.5, ♀—10:10:15:12. Pronotum less than half as long as maximal width (♂—35:73, ♀—36:76); scutellum shorter than basal width (♂—31:40, ♀—34:40); abdomen longer than maximal width across segment IV (♂—95:90, ♀—103:100). Spiracles all ventral, placed far from the border.

Colour: uniformly black; rostrum and tarsi yellow brown.

Total length: ♂—7.52, ♀—8.40 mm.; width of pronotum: ♂—2.92, ♀—3.04 mm.; width of abdomen: ♂—3.60, ♀—4.00 mm.

Holotype: ♂, Australia, Victoria, Lorne—F. E. Wilson coll. 27.X.18; deposited in the South Australian Museum, Adelaide.

Allotype: ♀, New South Wales, Jindabine—F. E. Wilson coll. 26 Feb. 52; deposited in the same museum.

Paratypes: 1 ♂ and 2 ♀, collected with allotype; in the same, and author's collection.

It is a pleasure to dedicate this species to its collector, Mr. F. E. Wilson.

3. **Mezira elegans** n. sp.

At first sight this new species looks more like a Neotropical *Mezira* than an Australian species, however the hind border of pronotum is more deeply sinuate than in the Neotropical species.

Female. Elongate, slightly widening posteriorad; lateral borders of pronotum and abdomen finely serrate.

Head shorter than width through the eyes (18:22.5), or across postocular tubercles (18:24). Anterior process tapering forward (the apex is slightly mutilated) reaching over the middle of antennal segment I; antenniferous tubercles dentiform, acute, with parallel exterior borders, and slightly divergent tips, reaching to $\frac{1}{3}$ of antennal segment I. Eyes semiglobose, protruding. Postocular tubercles dentiform, distinctly produced beyond outer border of eyes; infraocular carinae low, granulate, vertex roughly granulate; mesad of eyes are placed two (1 + 1) ovate callosities. Antennae robust; antennal segment I strongly dilated toward the tip; II tapering toward the

base, other missing; proportions, I to II, are: 8:9:-:-. Rostrum does not reach to the base of a deep rostral groove; the latter is open posteriorly.

Pronotum half as long as maximal width (22:44). Collar distinct, slightly sinuate in front; antero-lateral angles slightly expanded, rounded, produced as far as collar; lateral borders slightly convex; lateral notch absent; hind border deeply sinuate in the middle, convex laterally. Fore disc with four (2 + 2) low, oblique ridges; depressed between them. Hind disc evenly granulate; granulation setigerous, setae very fine and very short.

Scutellum shorter than basal width (22:25); all borders finely carinate; lateral borders straight, slightly sinuate near the tip; the latter incised. Disc flat, finely transversely rugose; median carina thin and low.

Hemelytra reach to $\frac{2}{3}$ of tergum VI; corium reaches almost to posterior border of connexivum III; baso-lateral border carinate, straight; apical border straight, not sinuate interiorly, and carinate; apical angle acute; membrane finely granulate.

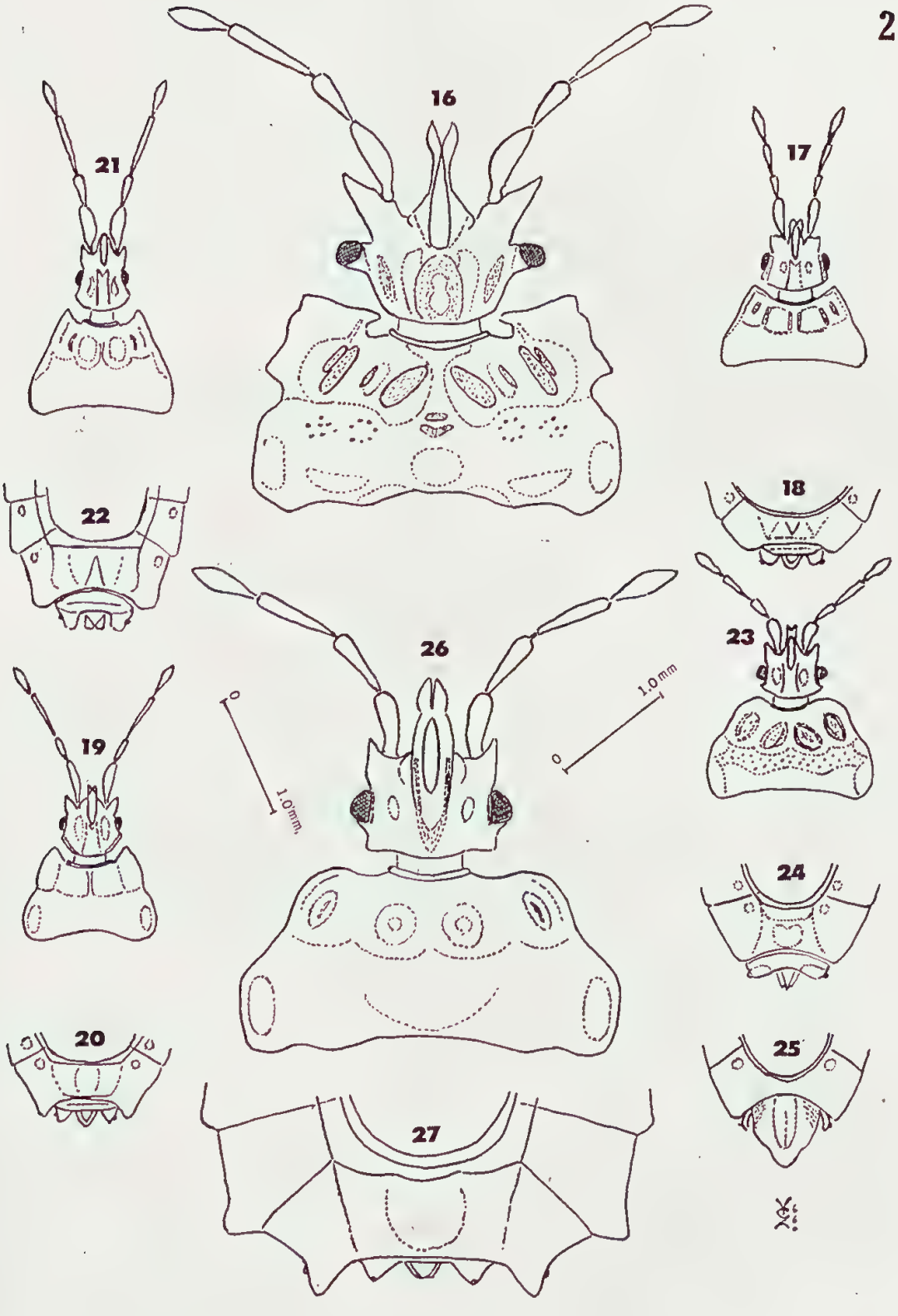
Abdomen longer than maximal width across segment IV (81:55); lateral borders evenly rounded; midlateral area half as wide as connexivum; connexiva longer than wide, flat, discs roughish; exterior borders of connexiva finely serrate; PE-angles not protruding; PE-VII rounded. Paratergites large, rounded, divergent, reaching to $\frac{3}{4}$ of IX; the latter tricuspidate, but valves slightly longer than oviduct. All spiracles ventral, placed far from the border.

Legs unarmed.

Colour: dark ferrugineous; connexivum bicolorous; light ferrugineous inside, in sharp contrast, dark ferrugineous at exterior border. Rostrum and tarsi light ferrugineous. Venter pale ferrugineous; genital segments and exterior borders dark ferrugineous.

Total length, 5.80 mm.; width of pronotum, 1.76 mm.; width of abdomen, 2.20 mm.

Fig. 16. Head and pronotum of *Artabanus mcfarlandi* n. sp.
Fig. 17. Head and pronotum of *Pictinellus moturikiensis* n. sp.
Fig. 18. Termination of abdomen of *Pictinellus moturikiensis* n. sp.
Fig. 19. Head and pronotum of *Pictinellus elongatus* n. sp.
Fig. 20. Termination of abdomen of *Pictinellus elongatus* n. sp.
Fig. 21. Head and pronotum of *Pictinellus longiceps* n. sp.
Fig. 22. Termination of abdomen of *Pictinellus longiceps* n. sp.
Fig. 23. Head and pronotum of *Pictinellus malayensis* n. sp.
Fig. 24. Termination of abdomen of *Pictinellus malayensis* n. sp. Female.
Fig. 25. Termination of abdomen of *Pictinellus malayensis* n. sp.
Fig. 26. Head and pronotum of *Mezira enigmatica* n. sp.
Fig. 27. Termination of abdomen of *Mezira enigmatica* n. sp.


2
16
21
17
22
18
26
23
19
1.0mm
1.0mm
24
20
25
27

Holotype: ♀, Australia, New South Wales, Dorrigo—W. Heron coll.; deposited in the South Australian Museum, Adelaide.

Mezira elegans n. sp. is quite distinct from all other Australian species of *Mezira*.

4. **Mezira sulcata** Kormilev

Mezira sulcata Kormilev, 1958, Jour. N.Y. Ent. Soc., **66**: 91.

This curious species is pretty common in Queensland.

2 ♀, Queensland, Kuranda—F. P. Dodd coll.; 11 ♂ and 11 ♀, Queensland, Cairns Distr.—A. M. Lea coll.; 4 ♂ and 6 ♀, Queensland, Cairns Distr.—E. Allen coll.

5. **Mezira subtriangula** Kormilev

Mezira subtriangula Kormilev, 1957, Ann. Mag. Nat. Hist., (12) **10**: 269.

Numerous specimens from N. New Guinea and Papua, and also from Bougainville, Solomon Islands.

6. **Mezira membranacea** Fabricius

Aradus membranaceus Fabricius, 1803, Syst. Rhyng., p. 118.

Brachyrhynchus membranaceus Stål, 1868, Hem. Fabr., **1**: 96.

Mezira membranacea Kormilev, 1953, Verh. Naturf. Ges., Basel, **64**: 333.

Widely distributed in the Oriental Region, penetrating into New Guinea. Recently it has been found in Hawaii (imported). This species breaks up into various geographical subspecies, one of which is *M. micronesica* Esaki and Matsuda, 1951, from Micronesia. Though specimens from Micronesia show some small differences to the nymotypic form of *M. membranacea*, including the parameres, sharp limits between them are impossible to determine.

In this lot were numerous specimens from New Guinea, New Britain, Solomon Islands, and Fiji, Viti Levu, which I refer to *M. membranacea micronesica* Esaki and Matsuda, rather than to *M. membranacea*.

Note.—Recently Blöte published a Catalogue of the Aradidae in the Rijksmuseum van Natuurlijke Historia in Leiden (1965: 1-41) in which he put *Daulocoris auritomentosa* (Kormilev 1955), into the synonymy of *Daulocoris feanus* (Bergroth 1889). With this I cannot concur, because they are certainly two different species, and easy to distinguish: in *D. feanus* the anterior process of the head only reaches to the tip of antennal segment I; the antero-lateral angles of the pronotum have expanded lateral borders placed more longitudinally,

and the postocular tubercles directed slightly forward. In *D. auritomentosa* the anterior process of the head is distinctly produced beyond the tip of antennal segment I; the lateral borders of the antero-lateral angles of the pronotum are placed more obliquely, and the postocular tubercles are directed sideways.

7. **Mezira enigmatica** n. sp.

Fig. 26-27.

This species stands apart from all other species of the genus, particularly in its angular postocular borders, practically without tubercles; by its sinuate lateral borders of the abdomen, which diverge posteriorly; all of which are more indicative of the genus *Arictus* Stål, than of *Mezira* A.S., and by spiracles VII being ventro-lateral in position, and clearly visible from above. But the general aspect of the body is that of *Mezira,* and this is where I am putting it tentatively, at least until a general revision of the genus.

Female. Elongate ovate, widening posteriorly; evenly covered with fine, black incrustation, looking like dirt, through which pass microscopical, erect, white hairs; under this incrustation the body is black and shiny.

Head longer than width through the eyes (36:33). Anterior process long, constricted in the middle, and narrowly incised in front, produced far beyond the tip of antennal segment I. Antenniferous tubercles dentiform, acute, slightly divaricating, reaching to $\frac{2}{5}$ of antennal segment I. Eyes semiglobose, protruding. Postocular borders angular and not reaching to outer border of eyes; infraocular carina very low, practically absent; vertex with "V"-shaped granulate carinae, obliterated by incrustation. Antennae strong, more than one and a half times as long as the head (59:36); antennal segment I clavate, slightly curved sideways; II and III tapering toward the base IV fusiform. Proportions of antennal segments, I to IV, are: 14:14:17:14. Rostrum reaches to fore border of prosternum; rostral atrium narrowly open; rostral groove wide and deep, transversely rugose, and open posteriorly.

Pronotum shorter than maximal width (34:75), divided into two lobes by a deep furrow; fore lobe much narrower than hind lobe (52:75). Collar fine, sinuate in front; antero-lateral angles slightly expanded, rounded, produced anteriorly as far as collar. Lateral borders slightly converging posteriorly, strongly converging and slightly sinuate anteriorly. Hind border widely sinuate in the middle, and then again slightly sinuate mesad of rounded posterior angles.

Fore disc with two (1 + 1) high, rounded elevations, and a depression between them; two (1 + 1) smaller longitudinal ridges placed laterally near lateral borders. Hind disc granulate.

Scutellum shorter than basal width (35:45); all borders carinate; lateral borders straight, tip rounded; disc granulate, with cross-shaped median carina.

Hemelytra reach almost to hind border of tergum VI; baso-lateral border of corium carinate, and slightly sinuate; apical angle acute; apical border twice shallowly sinuate. Membrane with anastomosing veins.

Abdomen slightly shorter than width across segment V (95:98). Lateral borders divergent, and slightly convex from II to V; slightly receding at VI; strongly receding, and sinuate at VII. PE-angles from II to V progressively protruding, rounded; PE-VI form a right angle with a rounded tip; PE-VII form a subtriangular lobe, directed backward; its rounded tip is produced beyond the tips of paratergites. Paratergites triangular, produced as far as IX; the latter trapezoidal, truncate posteriorly. Spiracles II to VI ventral, placed far from the border; VII ventro-lateral, clearly visible from above; VIII terminal.

Metathoracic gland openings short, and wide open, almost reaching the lateral border. Sternum VI widely sinuate posteriorly; sterna III to V with a triangular, VI with an ovate, callous spot medially.

Legs unarmed; trochanters free; thin, seta-like arolia are present.

Colour: black; rostrum, trochanters, callous spots on venter, tarsi, and apical half of antennal segment IV, red brown.

Total length, 8.12 mm.; width of pronotum, 3.00 mm.; width of abdomen, 3.82 mm.

Holotype: ♀, New Guinea, N.E. Papua, Mt. Lamington—C. T. McNamara coll.; deposited in the South Australian Museum, Adelaide.

REFERENCES

Blöte, H. C., 1965: Catalogue of the Aradidae in the Rijksmuseum van Natuurlijke Historie, Zool. Verh.; No. 75, pp. 1-41, 37 figs.

Usinger, R. L. and Matsuda, R., 1959: Classification of the Aradidae, British Museum (N.H.), London; 410-VII pp. 101 figs.

RESUMEN ESPAÑOL

En la segunda parte de los Arádidos del Museo de Australia del Sur, en Adelaide, el autor ha tratado la subfamília Mezirinae Oshanin, 1908. Tres géneros y diecinueve espécies resultaron ser nuevos para la ciencia y han sido descritos en este trabajo. De un interés particular es un género nuevo termitófilo de Australia Occidental, llamado *Aspisocoris termitophilus* n. g., n. sp.

APPENDIX—TYPE REGISTRATIONS

Due to an oversight when the first part of Mr. Kormilev's paper was published, the registration numbers being placed on the new type material were omitted from the text.

To maintain the same format registration numbers have similarly been omitted from this, the second and last part of Mr. Kormilev's present studies.

The registration numbers for the type material of *both* papers are given below.

Species.	Status.	Registration Number(s).
Aradus erraticus Kormilev	Holotype	I 20,280
Aradus fuscicornis Kormilev	Holotype	I 20,281
	Allotype	I 20,282
	Paratypes	I 20,283-20,290
Calisius grossi Kormilev	Holotype	I 20,291
Calisius leai Kormilev	Holotype	I 20,292
Calisius magdalenae Kormilev	Holotype	I 20,293
	Allotype	I 20,294
	Paratype	I 20,295
Calisius notabilis Kormilev	Holotype	I 20,296
Calisius septimus Kormilev	Holotype	I 20,297
Carventus brachypterus Kormilev	Holotype	I 20,298
Carventus malayensis Kormilev	Holotype	I 20,299
Carventus ovatus Kormilev	Holotype	I 20,300
	Paratype	I 20,301
Carventus robustus Kormilev	Holotype	I 20,302
	Allotype	I 20,303
	Paratypes	I 20,304-20,312
Acaraptera dimorpha Kormilev	Holotype	I 20,313
	Allotype	I 20,314
Acaraptera minuta Kormilev	Holotype	I 20,315
	Paratypes	I 20,316-7
Acaraptera (*Lissaptera*) *denticeps* Kormilev	Holotype	I 20,318
Mastigocoris malayensis Kormilev	Holotype	I 20,319
	Allotype	I 20,320
	Paratypes	I 20,321-20,331
Aspisocoris termitophilus Kormilev	Holotype	I 20,332
	Allotype	I 20,333
	Paratypes	I 20,334-20,340

Species.	Status.	Registration Number(s).
Artabanellus mcnamarai Kormilev . . .	Holotype	I 20,341
Argocoris grossi Kormilev	Holotype	I 20,342
Aegisocoris granulatus Kormilev	Holotype	I 20,343
Neophloeobia tuberculata Kormilev . . .	Holotype	I 20,344
Artabanus bilobiceps papuasicus Kormilev	Holotype	I 20,357
	Allotype	I 20,358
	Paratypes	I 20,359-20,360
Artabanus truncatus Kormilev	Holotype	I 20,361
Artabanus tuberculatus Kormilev	Holotype	I 20,362
Artabanus mcfarlandi Kormilev	Holotype	I 20,363
	Allotype	I 20,364
	Paratypes	I 20,365-20,371
Ctenoneurus aberrans Kormilev	Holotype	I 20,372
Pictinellus papuasicus Kormilev	Holotype	I 20,373
Pictinellus leai Kormilev	Holotype	I 20,374
	Paratypes	I 20,375-7
Pictinellus moturikiensis Kormilev . . .	Holotype	I 20,378
	Allotype	I 20,379
	Paratypes	I 20,380-2
Pictinellus elongatus Kormilev	Holotype	I 20,383
	Allotype	I 20,384
Pictinellus longiceps Kormilev	Holotype	I 20,385
Pictinellus malayensis Kormilev	Holotype	I 20,386
	Allotype	I 20,387
	Paratypes	I 20,388-9
Mezira wilsoni Kormilev	Holotype	I 20,390
	Allotype	I 20,391
	Paratype	I 20,392
Mezira elegans Kormilev	Holotype	I 20,393
Mezira enigmatica Kormilev	Holotype	I 20,394

G. F. G.

CORRECTIONS IN THE SYSTEMATIC POSITION OF CERTAIN TAXA OF THE CHALCIDOIDEA AND PROCTOTRUPOIDEA (s.l.)*, WITH NOTES ON SYNONYMY

By PAUL DESSART, Bruxelles

SUMMARY

The author describes the taxonomic confusion that has existed in the Proctotrupoidea and Chalcidoidea (Hymenoptera) and cites examples of species first described as Chalcidoidea and later transferred to Proctotrupoidea, and *vice versa*. The author makes the following new dispositions and synonymies: (i) *Agonophorus* Dahlbohm 1858 is synonymised with *Ismarus* Haliday 1835 (Proctotrupoidea-Diapriidae-Belytinae). (ii) *Pseudoceraphron pulex* Dodd 1924 is transferred from Proctotrupoidea-Ceraphronidae-Megaspilinae to Chalcidoidea-Pteromalidae-Diparinae. (iii) The new specific name *melantatocephalus* is proposed for *Ceraphron melanocephalus* Ashmead 1886, *non* Boheman 1832.

INTRODUCTION

In the past many species, and even genera, of Microhymenoptera have been shifted from the family or even superfamily in which they were originally described to another. Between the Chalcidoidea and Proctotrupoidea particularly there has been a considerable two way traffic.

The changes are especially common in the last century, or for species described in the last century. Then, or at least in the earlier half of the century, the systematics of the higher taxa of the Microhymenoptera was, to say the least, rudimentary and the superfamilies Ichneumonoidea, Cynipoidea, Chalcidoidea, and Proctotrupoidea not clearly defined, or even erected.

Some examples worth mentioning in order to further clarify the position are condensed in the following paragraphs.

Copidosoma melanocephalum Ashmead 1886 was described as a Pteromalid (Chalcidoidea). In 1893 Ashmead himself decided it was in fact a species of *Ceraphron* (Proctotrupoidea-Ceraphronidae).

* In the present note the Ceraphronidae are still considered a family of Proctotrupoidea. After this paper was submitted for publication, Dr. Masner and myself (see Masner, Lubomir and Dessart, Paul) have come to the conclusion that the Ceraphronidae are not related to the Proctotrupoidea but worthy of full superfamily status.

However the name *melanocephalum* in *Ceraphron* is preoccupied by *melanocephalus* Boheman 1832. Accordingly I am proposing the new name *Ceraphron melantatocephalus* nom. nov. for *Ceraphron melanocephalus* (Ashmead 1886) *non* Boheman 1832.

Chirocerus floridanus Ashmead 1881, described as a Pteromalid also is a Ceraphronid and belongs to the genus *Lygocerus* (*fide* Cresson 1887).

Elaptus (*laps. calami* for *Alaptus*) *aleurodis* Forbes 1884 (or 1885?) and *Anaphes mellicornis* Ashmead 1887 are not Mymarids but are both junior synonyms of *Amitus aleurodinis* Haldeman 1850 (Platygasteridae) according to Ashmead 1893 and Gahan 1927.

Paphagus rugosus Provancher 1881 is not a Pteromalid but is a species of *Stictoteleia* (*fide* Burks in Krombein 1958) and similarly *Sphalangia aenea* Provancher 1887 is a species of *Trimorus* (*fide* Burks *loc. cit.*), both genera of Scelionidae.

The specimens apparently misidentified as *Pteromalus ovulorum* by Boyer de Fonscolombe (1832, p. 303) have been variously interpreted by subsequent authors. In the *Addenda* (p. 432) to his classic work on the Microhymenoptera Nees (1834) placed them into the new genus *Myina* which he had erected earlier (p. 189) in this same work. Dalle Torre (1898) in his Catalogus Hymenopterorum cited them in three different places under three different names:—On page 264 as a possible synonym of *Encyrtus tardus* Ratzeburg 1844, on page 426 as a synonym of *Polynema ovulorum* Linné 1758, whilst on page 518 their reference by Nees as *Myina ovulorum* is erroneously transscribed *Mymar ovulorum* which is given as a synonym of *Telenomus ovulorum* Bouché 1834. Schmiedeknecht (1926) chose *Polynema ovulorum* from the three alternatives presented by Dalle Torre, however in the same year (1926) Kieffer cited "*Mymar O.* Nees, 1834, p. 432" (*i.e.*, *Myina* or *Pteromalus ovulorum* Fonscolombe) as a possible synonym of *Telenomus terebrans* (Ratzeburg 1834) a blackish Scelionid (Fonscolombe actually described his species as "*aeneus*").

Diapria conica (Fabricius 1775) a Diapriid has been successively called *Ichneumon conicus* (Fabricius in 1775), *Cynips crassipes* (Fourcroy in 1785), *?Cynipsichneumon conicus* (Christ in 1791) and *Chalcis conica* (Fabricius in 1798).

Schulz (1910) redescribed what he took to be a *Litus cynipseus* Haliday 1833, a Mymarid, whereas he actually had the Scelionid *Tiphodytes gerriphagus* (Marchal 1900) before him (*fide* Debauche 1948).

In Ashmead's monograph of Chalcids (1904) he moved into the Proctotrupids the genera *Agonophorus* Dalman (actually Dahlbom 1858), *Macrostigma* Rondani 1877, and *Trichacis* Provancher 1887 (p. 207) (actually Provancher's genus was called *Trichasius* and the page reference is wrong, it is actually p. 209; *Trichacis* is a Förster genus of 1856). Ashmead placed *Trichasius* Provancher as a synonym of *Baeus* Haliday 1833 (Proctotrupoidea-Scelionidae). Brues four years later (1908, p. 25) on the contrary considered *Trichasius* to be a synonym of *Gryon* Haliday 1833, another Scelionid genus he knew through Ashmead's earlier monograph of 1898. But on the eve of publication he discovered that Kieffer only a few months before had demonstrated that Ashmead has misinterpreted *Gryon* and had therefore erected the new genus *Paragryon* for *Gryon sensu* Ashmead *non* Haliday 1833 *nec* Förster 1856. Brues mentioned this point in the Appendix to his 1908 work (p. 49). Subsequently (1910) Kieffer in turn published a set of *Addenda et Corrigenda* to Brues' work in which he moved *Trichasius* Provancher back into the synonymy of *Baeus* Haliday and reaffirmed his opinion in his posthumous 1926 monograph (where it is misspelt *Trichariüs*). The further resolution of its status did not come until Muesebeck (1956) examined Provancher's type and found that it belongs to Kieffer's taxon *Paragryon* which becomes then the junior synonym of *Trichasius* Provancher 1887. *Macrostigma* Rondani 1877 was synonymized with *Megastigmus* Dalman (actually this is an error, which Ashmead corrected himself, for *Megaspilus* Westwood 1829). I re-examined one syntype and found that it belongs instead in the synonymy of *Lygocerus* Förster 1856 (Dessart 1966). Ashmead was not precise in placing *Agonophorus* Dahlbom 1858 in any particular position in the "Proctotrypoidea". Recently on a visit to the Entomologiska Institutionen of Lund University I was fortunate to find amongst the boxes of Dahlbom's unclassified material one specimen bearing the label *Agonophorus* and agreeing with the original brief description Dahlbom gave for the genus. My examination of this type showed clearly that *Agonophorus* Dahlbom 1858 is a straight junior synonym of *Ismarus* Haliday 1835 (Proctotrupoidea-Diapriidae-Belytinae) (*syn. nov.*).

As examples of transfers in the opposite direction, from the Proctotrupoidea to the Chalcidoidea, we may take the following cases.

Ceraphron destructor Say 1817 is not a Ceraphronidae, but a Chalcid and now placed in the genus *Merisus* Walker 1834 (Pteromalidae) (Peck 1963), though according to Gahan (1933) the original series (which has been lost) must have included also a few

specimens of *Eupteromalus fulvipes* Forbes 1885 (now *E. subapterus* Riley 1885, *non fulvipes* Walker 1836).

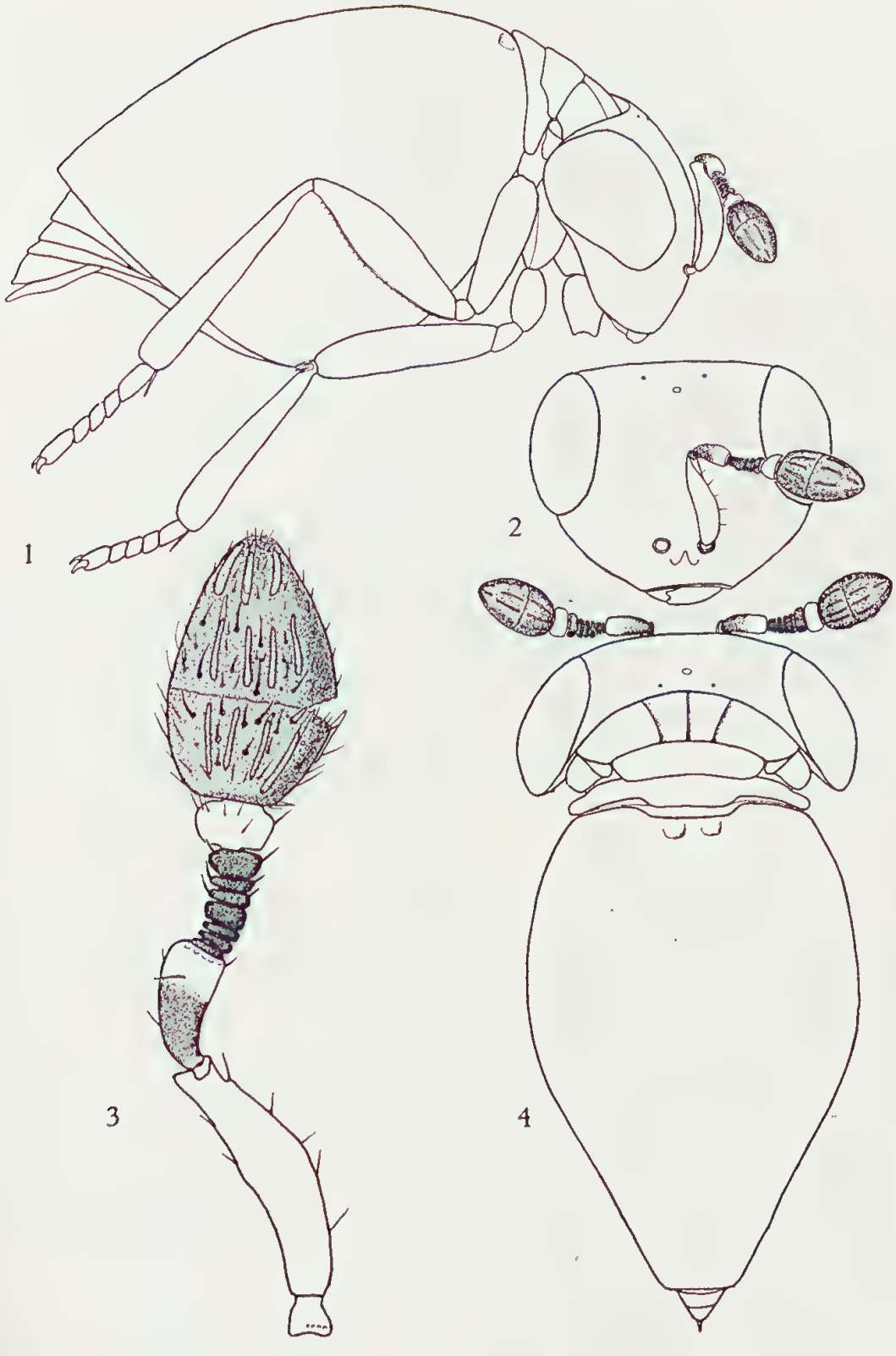
Psilus ciliatus Say 1828, successively placed in other genera of Diapriidae (*Galesus, Diapria, Trichopria*) is now considered a species of *Polynema* (Mymaridae).

Platygaster lecanii Fitch 1858 [1859] is not a Platygasteridae but a misidentification of *Coccophagus lycimnia* (Walker 1839) (Aphelinidae) (Peck 1963).

Serlion (!) *terminalis* Say 1828 (who meant *Scelio*) does not belong to the Scelionidae at all but to the genus *Homalotylus* Mayr 1875 (Encyrtidae).

Ceraphron syrphii Bouché 1834 was erroneously transferred by Nees (1834) to the genus *Eupelmus* Dalman 1820; it was later returned to the Ceraphronidae and passed through various genera: *Megaspilus* Westwood 1829, then *Trichosteresis* Förster 1856 (*fide* Kieffer 1914). *Diapria cecidomyiarum* Bouché 1834 is not a Diapriid but probably a species of *Eulophus* Geoffroy 1762 (*fide* Dalla Torre 1898) or of *Tetrastichus* Haliday 1843 (*fide* Schmiedeknecht 1909).

The genus *Trimicrops* Kieffer 1906, originally described as a Ceraphronid, was recognized later by Ferrière (in Beier 1930; see also Masner 1957, p. 83, Dessart 1962, p. 305) as a Chalcidoid (Pteromalidae-Diparinae). The drawing published by Ferrière (1930, p. 402, fig. 4a) leaves no doubt on the matter; the antenna is formed of a scape, the pedicel, three annuli, five funicular segments and a composite club in which from the two sutures one may deduce that it is formed of three segments, *i.e.*, 13 segments in all (although in fig. 3 of the same note, there are only two annuli left and thus, 12 segments). "Sensorial crests" (*sensu* Debauche, 1948, pp. 25 *et seq.*) are present on all funicular and club segments. Kieffer (1906, 1907, and 1909) described the antenna as ten segmented, which prompted him to place the genus in the Ceraphroninae (in the present sense of the term), at least by implication and based on where he places it among the other genera [Kieffer in these three publications, did not accept the subdivision proposed by Ashmead (1893)]. His error in the count of the antennal segments came about for two reasons: he confused on the one hand the two first annuli, and on the other hand the three club segments, as is clearly shown in the drawing published in the three works cited above. But it is surprising that in his monograph of 1914, next to two drawings (fig. 63 and 67) showing respectively the appearance of the insect from above, and the head in profile (both with *ten*-segmented antennae), another figure (fig. 66) shows a whole, *eleven*-segmented antenna, with the first two annuli clearly distinct. This drawing was



Figs. 1-4. *Pseudoceraphron pulex* Dodd 1924, after the holotype. 1. Habitus, lateral view. 2. Head, frontal view. 3. Antenna; total length of the scape: 150μ, of the club: 138μ. 4. Habitus, dorsal view; maximum width of the metasoma: 430μ.

probably made by an usher or a pupil of the college of Bitche where Kieffer taught. Whenever he noticed an error of his own making Kieffer as a rule apparently discreetly corrected it (*fide* Dessart, 1963, p. 10). As he said nothing about this discrepancy before he died 11 years later (1925, Dec. 30th) we may deduce that Kieffer did not notice this important point. If he had he could not have done other than to transfer the genus to the Megasilinae, because from 1914 onwards he had at last accepted that the Ceraphronidae should be divided into two subfamilies.

The history of the preceding case has been developed on purpose, for I have just found a similar one. Thanks to the courtesy of Mr. G. F. Gross of the South Australian Museum, Adelaide, I have had the opportunity to examine the monotype of *Pseudoceraphron pulex* Dodd 1924. The slide-mounted antenna which I first received, convinced me immediately that the genus could by no means be a Ceraphronid but a Chalcoid, probably best placed in the Pteromalidae-Diparinae, according to the original description. The examination of the remainder of the type has confirmed my opinion. The antenna (fig. 3) is formed not of 11 joints but of a scape, pedicel, three annuli, five funicular segments, and a composite club, apparently of two segments (for only one transverse suture can be detected) but really of three segments if one accepts each of the three rows of sensorial crests as representing a segment. This would make the antennae 13 segmented. Although to all extents and purposes entirely correct, just reading the original description without at the same time seeing a specimen one tends not to realize the extreme oddness of this species (fig. 1, 2 and 4). It will be noticed, among other things, that the posterior margin of the eyes nearly reaches the level of the base of the metasoma; the pronotum is entirely hidden by the very concave posterior face of the head, the fore coxae are quite near the very small mouth parts; the hind coxae are completely flattened and articulated much higher than the middle and fore ones: the posterior part of the mesosoma is therefore very reduced; just behind the knees the tibiae bear two dorsal bifid, thickset spurs; the ventral surfaces of the hind femora are shortly spinulose; the fore legs, described as "somewhat swollen", with a "long, curved, simple apical spur" at the tibiae, are unfortunately lost; the median ocellus is quite flat and broader than the lateral ones which may not be functional.

Despite these very flat hind coxae, which are much larger than the fore ones (characters which are more characteristic of Elasmidae, Torymidae, or Ormyridae), this genus, with its wings apparently completely absent, its non-metallic pattern, and big first metasomatic tergite, seems to be an atypical but true Pteromalidae-Diparinae.

I am not so well acquainted with the literature on Chalcidoidea as to be sure that the genus has not been described as a synonym elsewhere and placed in a more correct taxonomic position by an author not interested in Proctotrupoids. In closing, one may well wonder why Dodd named the genus *Pseudoceraphron,* since its appearance does not in any way resemble the genus *Ceraphron* and moreover he did not even place it in the subfamily Ceraphroninae.

BIBLIOGRAPHY

Ashmead, William H.: *Studies on the North American Chalcididae, with description of new species from Florida.* Trans. amer. ent. Soc., 9 (1881), pp. xxix-xxxv; 13 (1886), pp. 125-135.

——— *Studies of the North-American Proctotrupidae, with descriptions of new species from Florida.* Canad. Ent., 19 (1887), pp. 125-132, 192-198.

——— *A Monograph of the North American Proctotrypidae.* Bull. U.S. nat. Mus., 45 (1893), 472 pp., 2 figs., 18 pls., 5 pp. refs.

——— *Classification of the Chalcid Flies or the Superfamily Chalcidoidea, with descriptions of new species in the Carnegie Museum, collected in South America by Herbert H. Smith.* Mem. Carnegie Mus 1-4 (jan. 1904), pp. i-xi, 225-532, pls. 31-39, 11 pp. refs.

Bouché, P. Fr.: *Naturgeschichte der Insekten, besonders in Hinsicht ihrer ersten Zustände als Larven und Puppen.* Berlin (1834), 216 pp., 10 pls.

Boyer De Fonscolombe, E. L. J. H.: *Monographia chalciditum Galloprovinciae circà aquas sextias degentium.* Ann. Sci. nat., 26 (1832), pp. 273-307.

Brues, Charles T.: *Hymenoptera. Fam. Scelionidae.* Gén. Ins., 80 (1908), 59 pp., 2 pls.

Burks, B. D. in Krombein, Karl V.: *Hymenoptera of America North of Mexico, Synoptic Catalog, First supplement.* U.S. Dept. Agric., Agric. Monogr., 2 (1958), 305 pp.

Christ, J. L.: *Naturgeschichte, Classification und Nomenclatur der Insecten vom Bienen, Wespen, und Ameisengeschlecht*; . . . Frankfurt am Main (1791), 535 pp., 60 pls.

Cresson, E. T.: *Synopsis of the Hymenoptera of America North of Mexico, together with a catalogue of the described species, and bibliography.* Trans. amer. ent. Soc., suppl. vol. (1887), iv + 350 pp.

Dahlbom, A. G.: *Svenska Smä-Ichneumonernas familjer och slägten.* Ofv. K. Vet.-Akad. Förh., 14, 1857 (1858), pp. 289-298.

Dalla Torre, C. G. de (C. W. von): *Catalogus Hymenopterorum hucusque descriptorum systematicus et synonymicus.* Lipsiae, vol. 5, *Chalcididae et Proctotrupidae* (1898), 598 pp.

Dalman, J. W.: *Försök till uppställning af Insektfamiljen Pteromalini, i synnerhet med afseende på de i Sverige funne arter.* K. Svenska Vet. Acad. 41 (1820), pp. 123-(174?), 340-385, 2 pls.

Debauche, Hubert Robert: *Étude sur les Mymarommidae et les Mymaridae de la Belgique (Hymenoptera Chalcidoidea).* Mem. Mus. R. Hist. nat. Belgique, 108 (1948), 248 pp., 10 figs., 24 pls. (301 figs.).

Dessart, Paul: *Contribution à l'étude des Hyménoptères Proctotrupoidea (I). Notes sur quelques Ceraphronidae africains et tableau dichotomique des genres.* Bull. Ann. Soc. R. Ent. Belgique, 98, no. 17 (août 1962), pp. 291-311, 9 figs., 16 refs.

——— *Contribution à l'étude des Ceratopogonidae (Diptera) (VII). Tableaux dichotomiques illustrés pour la détermination des Forcipomyia africains.* Mém. Inst. R. Sci. nat. Belgique (2e sér.), 72 (15 août 1963), 151 pp., 1 fig. + 16 pls. (121 figs.), 96 refs.

——— *Contribution à l'étude des Hyménoptères Proctotrupoidea (IX). Révision du genre Macrostigma Rondani, 1877 (Ceraphronidae, Megaspilinae).* Redia, 19, 1964-1965 (16 dec. 1965), pp. 157-163, figs. 11-15, 15 refs.

See also Masner, Lubomir and Dessart, Paul (1967).

Dodd, Alan P.: *Chalcidoidea and Proctotrupoidea from Lord Howe and Norfolk Islands, with descriptions of new genera and species.* Trans. Proc. R. Soc. South Australia, 48 (24 dec. 1924), pp. 162-186.

Fabricius, J. C.: *Systema Entomologiae sistens Insectorum classes, ordines, genera, species, adjectis synonymis, locis, descriptionibus.* Flensburgi et Lipsiae (1775), [30] + 832 pp.

———— *Supplementum Entomologiae systematicae.* Hafniae (1798), 2 + 572 pp.

Ferrière, Ch. in: Beier, Max: *Zoologische Forschungreise nach den Jonischen Inseln und dem Peloponnes.* XII. Teil. *Hymenoptera parasitica Bearbeitet von Ch. Ferrière. London.* SitzBer. Akad. Wiss. Wien (Math. Naturw. Kl.), Abt. I, 139 (1930), pp. 393-406, 4 figs.

Fitch, Asa: *Fifth Report on the noxious, beneficial and other Insects of the State of New York Made to the State Agricultural Society, pursuant to an approbation for this purpose from the Legislature of the State.* Trans. New York State agric. Soc., 1858 [1859], pp. 781-854.

Foerster, Arnold: *Hymenopterologische Studien.* II. Heft. *Chalcidiae und Proctotrupii.* Aachen (1856), 152 pp.

Fonscolombe: see Boyer De Fonscolombe.

Forbes, S. A.: (Title unknown). Ann. Rept. Stat. Ent. Ill. 14 (1884) [1885], p. 110.

Förster, A.: see Foerster.

Fourcroy, A. Fr.: *Entomologia parisiensis, sive catalogus Insectorum, quae in agro parisiensi reperiuntur, . . .* Paris (1785), 2 vol., 544 pp.

Gahan, A. B. and Fagan, Margaret M.: *The type species of the genera of the Chalcidoidea or chalcid-flies.* Bull. U.S. nat. Mus., 124 (1923), 173 pp.

Gahan, A. B.: *Miscellaneous observations of new parasitic Hymenoptera with some synonymical notes.* Proc. U.S. nat. Mus., 71, no. 2876 (1927), pp. 1-39, 3 figs., 1 pl.

———— *The serphoid and chalcidoid parasites of the Hessian fly.* U.S. Dept. Agric., misc. Publ., 174 (dec. 1933), 148 pp., 32 figs., refs.

Geoffroy, E. L.: *Histoire abrégée des insectes qui se trouvent aux environs de Paris, dans laquelle ces animaux sont rangés suivant un ordre méthodique.* Paris, 2 (1762), 690 pp., pls. 11-22.

Haldeman, S. S.: *On four new species of Hemiptera of the genera Ploiaria, Chermes, and Aleurodes; and two new Hymenoptera parasitic in the last named genus.* Amer. J. Sci. (2), 9 (1850), pp. 108-111.

Haliday, A. H.: *An Essay on the Classification of the Parasitic Hymenoptera of Britain, which correspond with the Ichneumones minuti of Linnaeus.* Ent. Mag., 1 (1833), pp. 259-276.

———— *Addenda et corrigenda,* p. 467, in: *Essay on Parasitic Hymenoptera (Continued . .). Of the Ichneumones Adsciti.* Ent. Mag., 2 (1835), pp. 458-467.

———— *Contribution towards the Classification of the Chalcididae.* Trans. ent. Soc. London, 3 (1843), pp. 295-301.

Kieffer, J. J.: *Description de nouveaux Hyménoptères.* Ann. Soc. sci. Bruxelles, Mém., 30, 1905-1906 (1906), pp. 113-178, 19 figs.

Kieffer, J. J. in André: *Species des Hyménoptères d'Europe et d'Algérie,* t. 10, *4e sous-famille. Ceraphroninae* (1907), pp. 5-261, pls. 1-8.

Kieffer, J. J.: *Révision des Scelionidae (Hyménoptères).* Ann. Soc. sci. Bruxelles, Mém., 32, 1907-1908 (1908), pp. 111-250, 16 figs. 1 pl.

———— *Hymenoptera. Fam. Ceraphronidae.* Gén. Ins., 94 (1909), 27 pp., 2 pls.

———— *Hymenoptera. Fam. Scelionidae. Addenda et corrigenda.* Gen. Ins., 80 bis (1910), pp. 61-112, 1 pl.

———— *Hymenoptera Proctotrupoidea. Serphidae (= Proctotrupidae) et Calliceratidae (= Ceraphronidae).* Das Tierreich, 42 (1914), xvii + 254 pp., 103 figs., 5 pp. refs.

———— (†) *Hymenoptera Proctotrupoidea. Scelionidae.* Das Tierreich, 48 (1926), xxxvi + 885 pp., 340 figs., 6 + 9 pp. refs.

Linné, Carl von.: *Systema Naturae . . .*, 10e éd., 1 (1758), 823 pp.

Marchal, P.: *Sur un nouvel Hyménoptère aquatique, le Limnodytes gerriphagus n. gen., n. sp.* Ann. Soc. ent. France (6e sér.), 69 (1900), pp. 171-176, figs. I-1—I-4 et II.1-II.3.

Masner, Lubomir: *Bemerkungen zur Gattung Elysoceraphron Szel.* (*Hym., Ceraphronoidea*). Nachtrichtenblatt Bayer. Ent., 6 (1957), pp. 81-84, 2 figs., 6 refs.

Masner, Lubomir et Dessart, Paul: *"La reclassification des catégories taxonomiques supérieurs des Ceraphronoidea"*. Bull. Inst. r. Sci. nat. Belgique, 43 no. 22 (1967).

Mayr, G. L.: *Die europäischen Encyrtiden, biologisch und systematisch bearbeitet.* Verh. zool.-bot. Ges. Wien, 25 (1875), pp. 675-778.

Muesebeck, C. F. W.: *New generic synonymy in the Scelionidae* (*Hymenoptera*). Proc. ent. Soc. Wash., 58-1 (feb. 1956), p. 24.

Muesebeck, C. F. W. and Walkley, Luella: *Type species of the genera and subgenera of parasitic wasps comprising the superfamily Proctotrupoidea* (*Order Hymenoptera*). Proc. U.S. nat. Mus., 105, no. 3359 (1956), pp. 319-419, index.

Nees ab Esenbeck, Christ. Godofr.: *Hymenopterorum Ichneumonibus affinium Monographiae, genera europaea et species illustrantes.* Stuttgartiae et Tubingae, 2 (1834), 448 pp.

Nixon, G. E. J.: *Hymenoptera Proctotrupoidea Diapriidae subfamily Belytinae.* Handbook Identif. British Ins., vol. VIII, Part 3 (*dii*) (31 dec. 1957), 107 pp., 314 figs.

Peck, Oswald: *A Catalogue of the Nearctic Chalcidoidea* (*Insecta: Hymenoptera*). Canad. Ent., Suppl. 30 (1963), 1092 pp.

Peck, Oswald, Boucek, Zdenek, and Hoffer, Augustin: *Keys to the Chalcidoidea of Czechoslovakia* (*Insecta: Hymenoptera*). Mem. ent. Soc. Canada, 34 (1964), 121 pp., 289 figs., index.

Provancher, Louis: *Faune Canadienne. Les Insectes-Hyménoptères.* Natur. Canad., 12 (1881), pp. 193-207, 225-241, 257-269, 291-304, 321-333, 353-362.

——— *Additions et corrections au volume II de la faune entomologique du Canada traitant des Hyménoptères.* Québec (1885-1889), 475 pp., 37 figs.

Riley, C. V.: *On the Parasites of the Hessian Fly.* Proc. U.S. nat. Mus., 8 (1885), pp. 413-422, pl. 23.

Rondani, C.: *Vesparia parasitica non vel minus cognita observata et descripta.* Bull. Soc. ent. ital., 9 (1877), pp. 166-213, pls. 3-6.

Say, Th.: *Some account of the insect known by the name of Hessian Fly and of a parasitic insect that feeds on it.* J. Acad. nat. Sci. Philadelphia, 1 (1817), pp. 45-48, 63-64, 1 pl.

——— *Descriptions of new species of Hymenoptera of the United States.* Contrib. Maclur. Lyceum Philadelphia, 1 (1828), pp. 67-83.

Schmiedeknecht, Otto: *Hymenoptera. Fam. Chalcididae.* Gen. Ins., 97 (1909), 550 pp., 8 pls.

Schulz, W. A.: *Neuer Beitrag zur Kenntnis der Wasserimmen.* Ann. Biol. lac. 4, 1909-1911 (1910), pp. 187-193, 4 figs.

Walker, Fr.: *Monographia Chalciditum.* Ent. Mag., 2 (1834), pp. 13-39, 148-179, 286-309, 340-369, 476-502; 3 (1836), pp. 94-98, 182-206, 465-496.

——— *Monographia Chalciditum.* London, 1 (1839), 333 pp.

Westwood, J. O. in Stephens, J. F.: *The nomenclature of British Insects,* London (1829), 68 colonnes.

ACKNOWLEDGMENT

The author is very grateful to Mr. G. F. Gross for pertinent suggestions and correction of the English text of manuscript.

RESUME

L'auteur présente une liste non exhaustive d'Hyménoptères décrits comme Chalcidoidea et transférés ensuite aux Proctotrupoidea, et *vice versa*. Comme nouveaux exemples, il précise le cas d'*Agonophorus* Dahlbom 1858, qu'il met en synonymie avec *Ismarus* Haliday 1835 (Proctotrupoidea, Diapriidae, Belytinae), *syn. nov.*, et transfère *Pseudoceraphron pulex* Dodd 1924, des Proctotrupoidea-Ceraphronidae-Megaspilinae aux Chalcidoidea-Pteromalidae-Diparinae, *stat. nov.* En outre, il propose *Ceraphron melantatocephalus nomen nov.* pour *Ceraphron melanocephalus* (Ashmead 1886), non Boheman 1832.

Institut Royal des Sciences naturelles de Belgique, April 1966.

AUSTRALITES FROM MYRTLE SPRINGS STATION, SOUTH AUSTRALIA

By DAVID W. P. CORBETT, Curator of Fossils and Minerals, South Australian Museum

SUMMARY

A hundred and seventy-five well preserved australites from Myrtle Springs Station are classified and assessed statistically. The high proportion of flanged forms (66%) indicates protection of the australites from severe terrestrial weathering since fall. Mode of occurrence and method of collection are described. Limited stratigraphic and archaeological evidence suggests a geologically very recent date for the fall. The relation of the Myrtle Springs australites to those known from adjacent areas is discussed.

INTRODUCTION

A collection of 175 australites was made by a South Australian Museum party during September, 1964, from Myrtle Springs Station, 12 miles west of Leigh Creek. Although australites had been picked up in the area by station workers over a number of years, the first systematic collecting was carried out by a joint American-Australian party in 1963 and again in 1964. Members of the party were Dr. Brian Mason, then of the American Museum of Natural History, New York; Mr. E. P. Henderson of the United States National Museum, Washington; and Mr. O. Chalmers of the Australian Museum, Sydney.

Several collectors have been in the area since 1964. The Myrtle Springs australites have attracted collectors because of their relative abundance and good state of preservation in an area which is comparatively easy of access.

Over the past decade, a large amount of published data has appeared on tektites in general and australites in particular. Much of this information has been of a chemical nature and very little attention has been given to the field occurrence of australites and their distribution over the various strewn-fields. A notable exception to this has been the detailed work of Baker in south-west Victoria (see references in Baker, 1963). It is characteristic that over most of the vast Australian strewn-field, the australites are found lying on the surface of the ground, and localities yielding stratigraphic information are rare. The Myrtle Springs area is one where with careful study such information is obtainable. This paper records the results of the survey by the South Australian Museum party.

THE MYRTLE SPRINGS STREWN-FIELD

Australites are found in an extensive belt of sand ridge country lying between Lake Torrens and the western margin of the Flinders Ranges. The collecting area of over 100 square miles is shown in fig. 1. From the available evidence, distribution of australites within this area is patchy, with local areas of concentration. No australites have been found east of Pine Dam, or along the eastern margins of Lake Torrens. Collections known from adjacent regions suggest that the Myrtle Springs field is part of a more extensive strewn-field embracing a large area to the north and south.

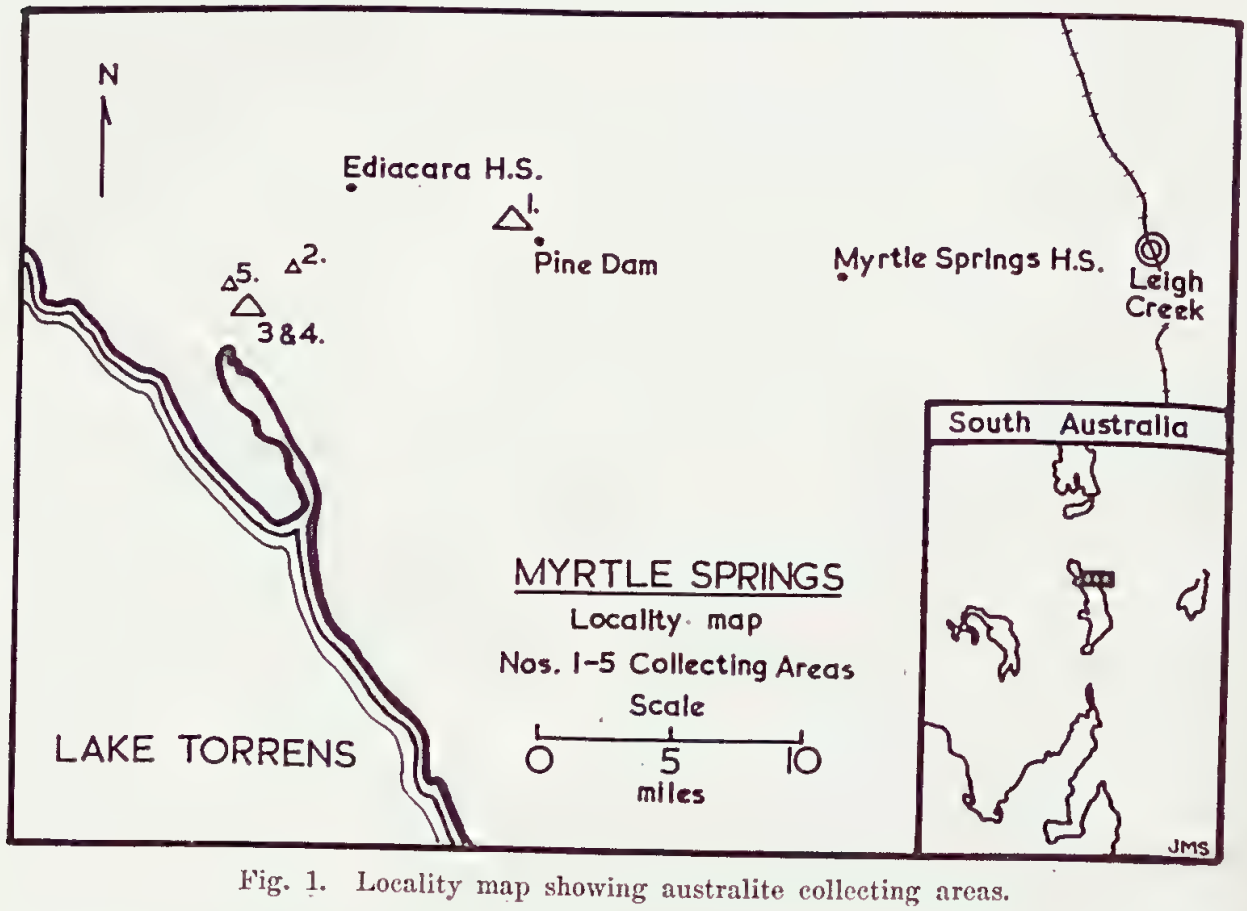


Fig. 1. Locality map showing australite collecting areas.

The general environment of the Myrtle Springs field is one of longitudinal sand ridges, oriented east-south-east, west-south-west. The ridges are sinuous and frequently converging, with the interdune corridors often containing claypans (fig. 2). The sand ridges reach a height of about 40 feet, and the interdune corridors average 300 yards in width.

The whole sand ridge system carries a sparse vegetation and is to a large extent "fixed", although there is evidence that considerable local movement of sand occurs periodically. A corridor was completely cut off by drift during the great drought of 1914.

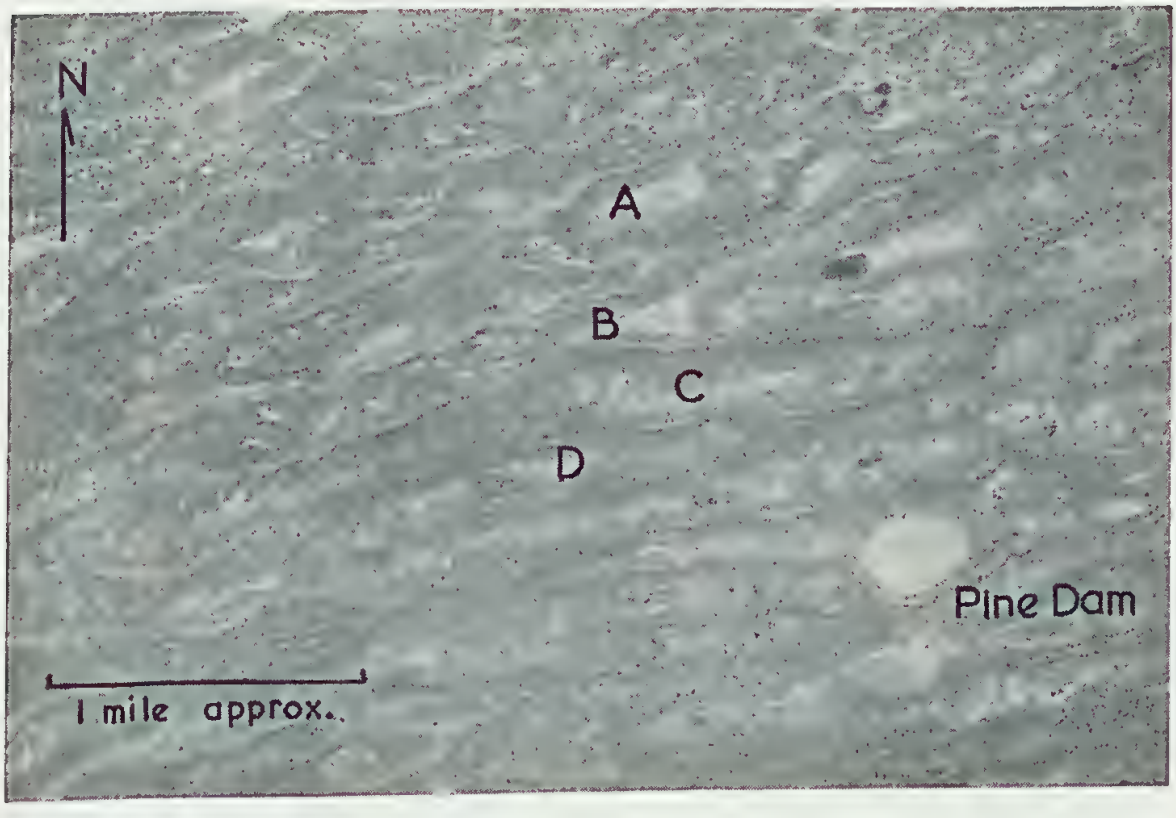


Fig. 2. Aerial photograph of area north-west of Pine Dam. The major part of the collection from Area 1 was made in corridors A-D. [Photo. courtesy the Director, Department of Lands, Adelaide.]

THE OCCURRENCE OF AUSTRALITES

All australites were found within the interdune corridors, with a marked concentration around the margins and with generally fewer specimens towards the centre. No australites were found within the sand ridges. It was noticeable after a little time spent in the area, that the australites were only present in those corridors where deflation had caused scouring to a sufficiently deep level to expose them, and it soon became possible to pick the likely corridors in which to search. It was also found that the australites were associated with a particular layer of red silt occurring beneath the cross-bedded dune sands. A concentration of australites along the outcrop of this layer was strongly evident. The situation is shown diagrammatically in fig. 3.

No australite was found entirely embedded in the red silt layer, but the concentration of finds at the level of this layer and the complete absence of australites from the dune sand above, support the view that the red silt is the layer from which the australites are weathering out at the present time.

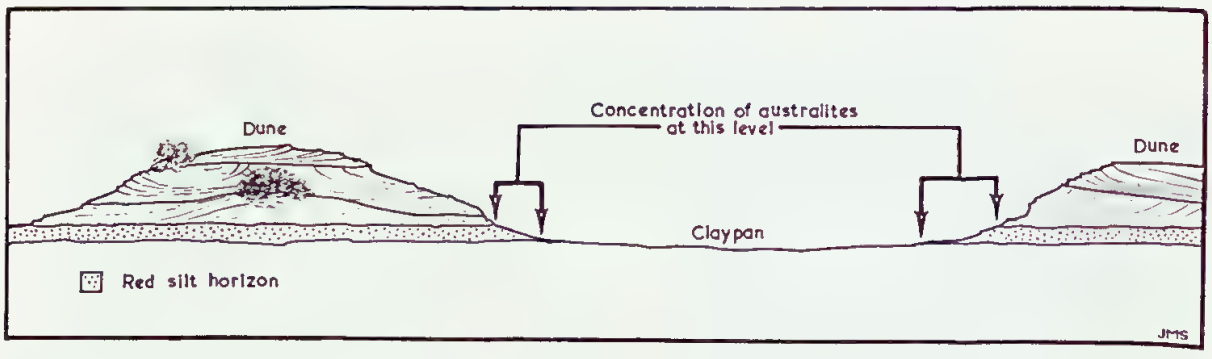


Fig. 3. Dune and claypan showing occurrence of australites along outcrop of red silt horizon. Diagrammatic section—not to scale.

The red silt was found to contain aboriginal stone implements of a type referable to the Pirrian culture in the culture sequence of Tindale (1957). The association of pirri-type implements with the australites at the red silt level proved consistent throughout the area investigated. Search was made in several corridors where deflation had not exposed the red silt, but no australites were found. Microlith implements were present, but were not associated with pirris.

Radiocarbon dates from two stratified native campsites in the Murray Valley of South Australia have given ages of 4,250 ± 180 for the mid-Pirrian at Devon Downs (*ibid* 1957) and 4,850 ± 100 from level 10 at Fromm's Landing, where pirri and microlith implements were found (Mulvaney, 1960). Although it is not possible to correlate with any certainty the Pirrian sites in the Murray Valley with the red silt level at Myrtle Springs, the evidence is sufficient to suggest that the terrestrial age of the australites is in the order of 4,000-5,000 years. This assessment is in accord with the recent work of Gill (1965) on a systematic excavation in south-west Victoria, where a successful attempt was made to obtain australites *in situ* for the purpose of determining their terrestrial ages.

It also supports the view of Baker (1960) that the australite fall was a geologically very recent event taking place some 5,000 years B.P. It is hopeful that further detailed work at Myrtle Springs will produce specimens definitely *in situ* and that refinement of the stratigraphic succession may provide further evidence for the date of the fall.

Insufficient is known about the post-Pleistocene history of the area to reconstruct the local environment at the time of australite fall. The fall may have taken place during the time of deposition of the red silt, or alternatively may have occurred at a time when the red silt was exposed, prior to burial by drifting sand. The marked contrast in structure between the red silt and the overlying dune sands

indicates the onset of increasingly arid conditions after the deposition of the red silt. In all probability the dune sands were derived locally by the reworking of this extensive red silt layer . The aeolian sands have effectively blanketed many australites since their fall; others have become exposed and suffered some measure of terrestrial weathering during the recent scouring of the interdune corridors by wind deflation.

Charcoal from a native hearth discovered on the outcrop of the red silt 1 mile north-west of Pine Dam, has given a radiocarbon age of 1,860 ± 110 years B.P., indicating that exposure of the australite-bearing layer is not wholly recent, and that some australites have suffered weathering over a longer period of time, or been exposed intermittently over several thousand years.

METHOD OF COLLECTION

Australites were collected from five areas within the strewn-field. Three of these were more productive than the other two, and this is indicated by the size of the triangles in fig. 1. Aerial photography was available for the area to the north-west of Pine Dam, and all locations of australites collected within this region were plotted on the photographs. In certain restricted areas where a concentration of specimens was found, the scale of the photographs (approximately 1.3 inches to the mile) did not permit individual plotting. Collecting areas 2-5 were not covered by the available photography, but have been located on the photo-mosaic of the Myrtle One-mile Sheet area.

All australites were picked up on the surface of the ground. Two specimens found partially embedded in the red silt layer are believed to be weathering out of this bed. A section cut vertically through the site of one of these specimens passed through 6 inches of red silt, overlying 10 inches of calcareous sand. The section was completed at 1 foot 4 inches in a hard nodular calcareous layer. This horizon was encountered in several of the deeply scoured corridors, and appears to represent the local base-level in the area.

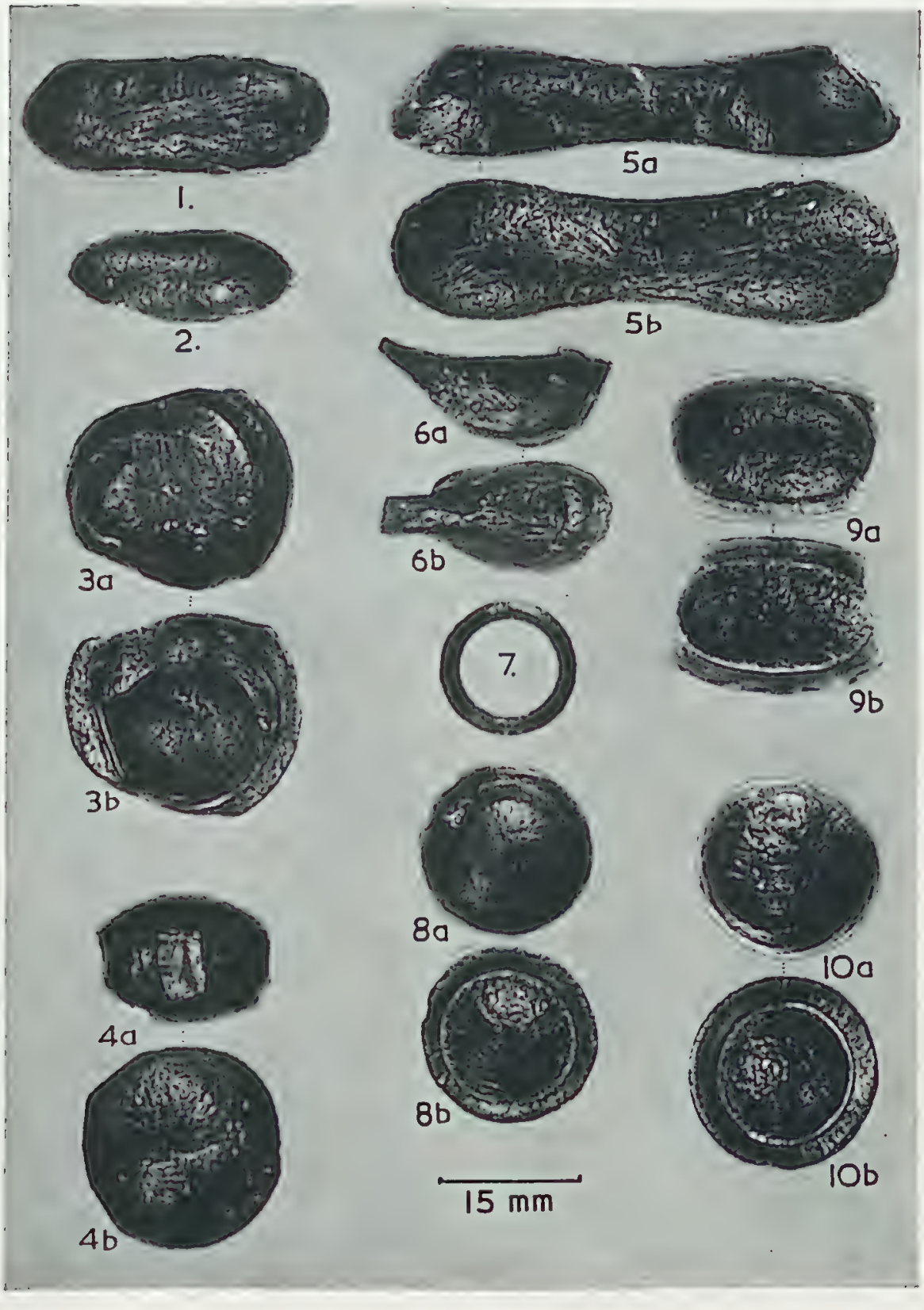
Previous writers have claimed that australites are more easily seen on the ground if the collector advances with the sun behind him, preferably in the late evening, when the characteristic lustre of the australites is enhanced (Mawson, 1958). This method may well be necessary in an area of stony ground where the australites are difficult to detect among the iron-stained gibber pebbles of similar shape and size. At Myrtle Springs, however, the australites are very conspicuous because of the paucity of other rock fragments, and collecting was not confined to any particular method or time of day.

DESCRIPTION OF THE AUSTRALITES

State of preservation: Most of the australites collected show little evidence of terrestrial weathering. The majority have retained their flanges, and flow ridges and other surface features are preserved. Those specimens that have been exposed to weathering since their fall show partial or complete loss of flange and the blurring of surface features due to abrasion. The general state of preservation of the specimens collected is consistent with their having been only recently exposed at the surface, by the erosion of the silt in which they occur. There has been minimal redistribution since fall, and many are believed to be little removed from their original landing place. Flanged buttons at three widely separated localities were found split into two parts by terrestrial weathering agencies, the separate parts being picked up within a few feet of each other. A large proportion of the flanged forms were found with their anterior surface uppermost, supporting the view of Baker (1956) that this is the stable position for australites lying on the earth's surface.

Australite shape groups: Examples of all the major shape groups listed by Baker (1963) are represented in the collection (see fig. 4 and 5). The numbers and percentages of the various groups are tabulated in table I. Of all the specimens collected, 66.30% were flanged. Two complete detached flanges were found. These are particularly rare and no other examples exist in the large South Australian Museum collection of some 17,000 specimens. The lenses, which comprise 12.57% of the total Myrtle Springs collection, were originally buttons, which have lost the greater part of their flanges due to terrestrial weathering. Even when all trace of the flange itself has gone, the flange scar is still retained, distinguishing this type of lens from that formed by loss of the flange during flight through the atmosphere. The weathered flanged buttons are indicative of a moderate amount of terrestrial abrasion and fragmentation, without these processes having been severe enough to mask the true original form of the specimens.

Fig. 4. Examples of the various australite shape groups from Myrtle Springs Station. 1. Boat, anterior view. 2. Canoe, anterior view. 3a. Hollow flanged button, anterior view showing flow ridges. 3b. Posterior view of 3a showing large bubble cavity with smaller bubble above. 4a. Core, side view showing equatorial flaking. 4b. Posterior view of 4a. 5a. Dumbbell, side view. 5b. Posterior view of 5a. 6a. Teardrop, side view. 6b. Posterior view of 6a. 7. Complete detached flange, anterior view. 8a. Flanged button, anterior view showing flow ridges and bubble pit near top left margin. 8b. Posterior view of 8a showing flow lines. 9a. Flanged oval, anterior view. 9b. Posterior view of 9a. 10a. Flanged button, anterior view. 10b. Posterior view of 10a.


1.
2.
3a
3b
4a
4b
5a
5b
6a
6b
7.
8a
8b
9a
9b
10a
10b
15 mm

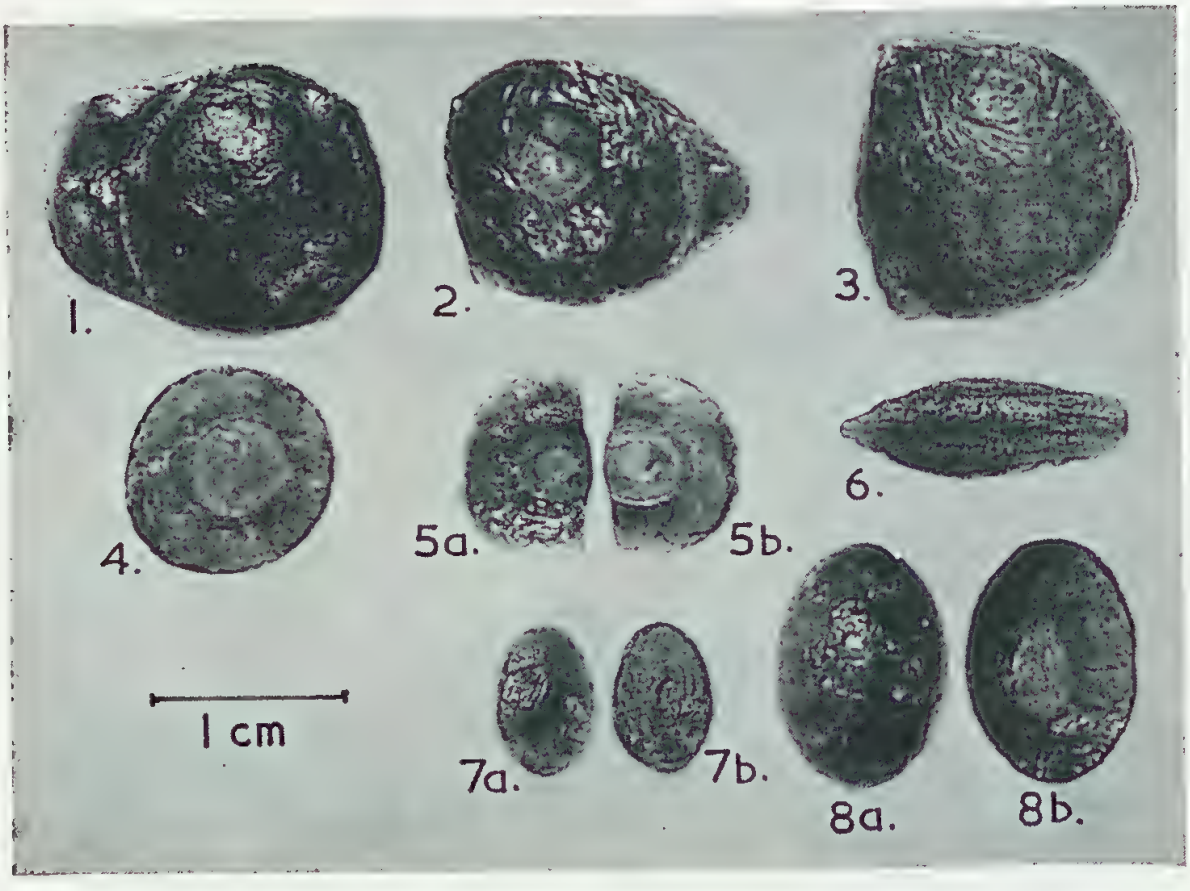


Fig. 5. Examples of the various australite shape groups from Myrtle Springs Station (continued). 1, 2 and 3. Posterior views of three lens forms (originally flanged buttons) showing progressive loss of flange due to weathering. 2. Exhibits a bubble crater. 4. Flat flanged disc showing flow lines in the central core. 5a and 5b. Anterior and posterior views of a thin flanged disc. 6. Thin teardrop-shaped australite with flow lines parallel to the length of the specimen. 7a and 7b, 8a and 8b. Anterior and posterior views of two bowl-shaped australites. In both specimens the central core is dominated by the wide flange.

There is a significant percentage (18.86%) of small complete australites of the flanged disc and bowl groups, the proportion reaching 30.36% in the collection from Area 4. It has been pointed out to the author by Mr. E. P. Henderson* that many of the flanged disc australites are capable of flotation, and it is possible that the concentration of these small forms in Area 4 and parts of Area 3 is due to the shepherding of these floating australites by gentle wave or current action to some quiet backwater where they have been stranded. Such an hypothesis implies that the australites fell into shallow water, possibly at a time when the red silt layer was being deposited, or subsequently when the outcrop of this layer was flooded. The local concentration of the flanged discs and bowls can alternatively be interpreted as representing the original fall pattern, with minimal

* Associate Curator-in-Charge, Division of Meteorites, U.S. National Museum, Washington. (Verbal communication.)

redistribution since that time. The absence of these small forms from most of the collections in the South Australian Museum is noticeable. It is impossible to assess from the available collections the relative abundance of the smaller australites in the original population from a given area, because in most cases collections were not made systematically. Small specimens may frequently have been overlooked, or regarded as insignificant and discarded. It is also to be expected that in areas where they have lain at the surface for a long period of time, the smallest specimens may not have survived the rigours of terrestrial weathering. Several small specimens, the lightest of 0.15 gm., have been described by Fenner (1934) from the Shaw collection of australites housed in this Museum. It is proposed to deal with the aerodynamic aspects of certain of the more interesting australites in the collection in a subsequent paper.

Weight: The total weight of australite material was 219.49 gm., an average of 1.25 gm. per specimen. Weight statistics are tabulated below.

TABLE I

Classification of the Myrtle Springs Australites

Australite Type	Area 1	Area 2	Area 3	Area 4	Area 5	Number of Specimens Collected	Per Cent of Total Collection	
Flanged Forms—								
Buttons	10	2	3	3	—	18	10.29	
Ovals	4	—	—	—	—	4	2.29	
Dumbbells	3	—	1	—	—	4	2.29	
Flanged fragments	16*	—	9	8*	2	35	20.00	
Discs	4	—	10	14	—	28	16.00	
Bowls	1	—	1	3	—	5	2.86	
Lenses with evidence of original flange.	11	—	5	6	—	22	12.57	
								66.30
Non-Flanged Forms—								
Lenses	2	—	1	1	—	4	2.29	
Dumbbells	3	—	—	—	—	3	1.71	
Boats	1	—	—	—	—	1	0.57	
Fragmentary boats	5	—	—	—	—	5	2.86	
Canoes	—	—	—	1	—	1	0.57	
Teardrops	3	—	3	2	—	8	4.57	
Cores	3	—	—	—	—	3	1.71	
Others	6	—	11	17	—	34	19.43	
								33.71
Totals	72	2	44	55	2	175		100.01

* Includes one complete detached flange

TABLE II

	Complete Collection	Area 1	Area 2	Area 3	Area 4	Area 5
Total number of specimens .	175	72	2	44	55	2
Total weight of material collected—(in grams)	219.49	148.18	7.31	27.82	33.84	2.34
Average weight of individual specimens	1.25	2.08	3.66	0.63	0.62	1.17
Weight range	0.08 –11.18	0.10 –11.18	—	0.11 –4.53	0.08 –6.66	—

Specific gravity: The specific gravity of all specimens weighing over 0.5 gm. was determined hydrostatically using a Mettler H5 balance and toluene as the liquid. The total of 89 individual readings was not sufficient to produce a statistically significant number of

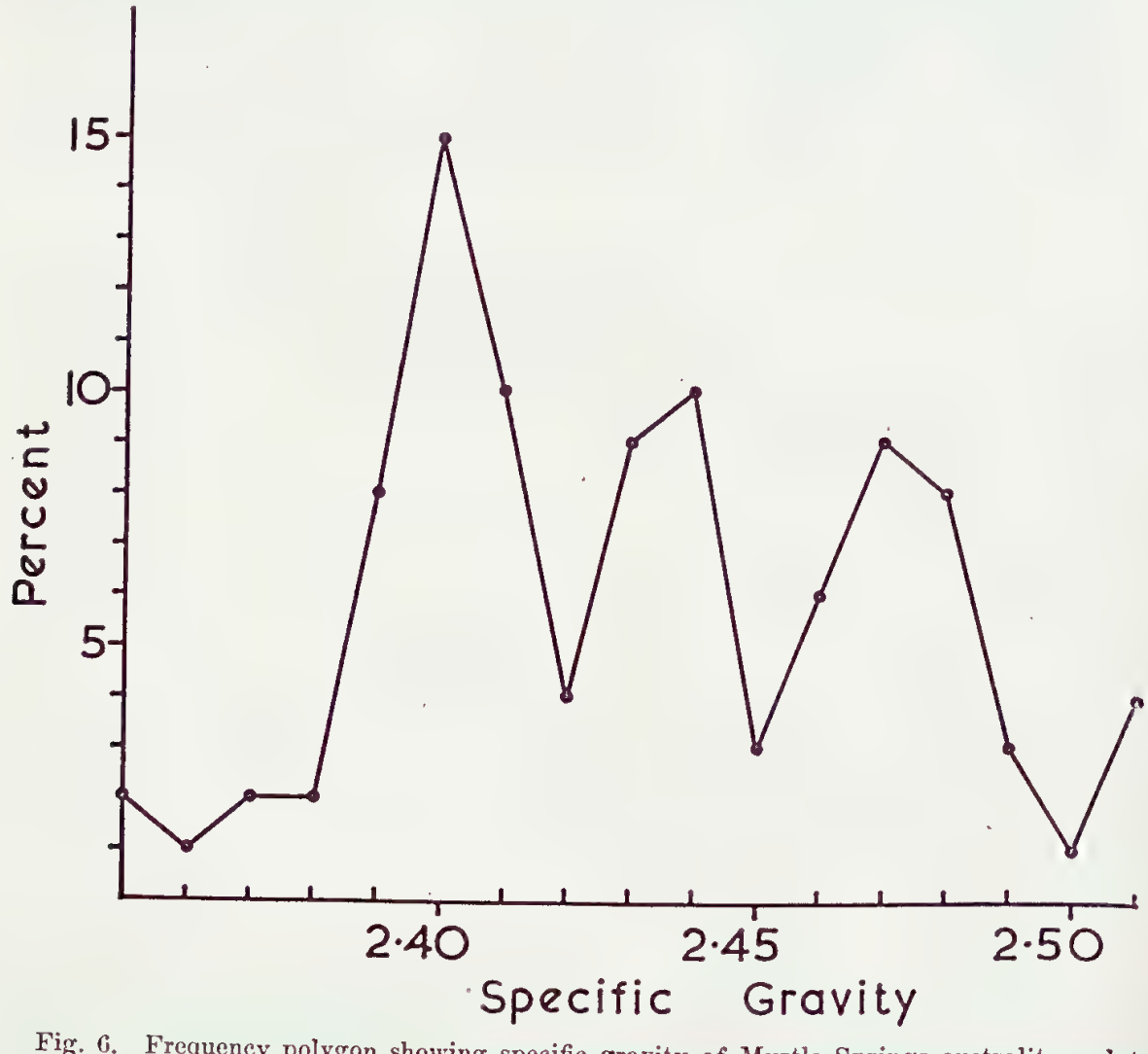


Fig. 6. Frequency polygon showing specific gravity of Myrtle Springs australites related to percentage of the whole collection.

points on the frequency polygon (fig. 6) which, because of the wide range in density, shows an irregular figure. The modal density is 2.40 with minor peaks at 2.44 and 2.47.

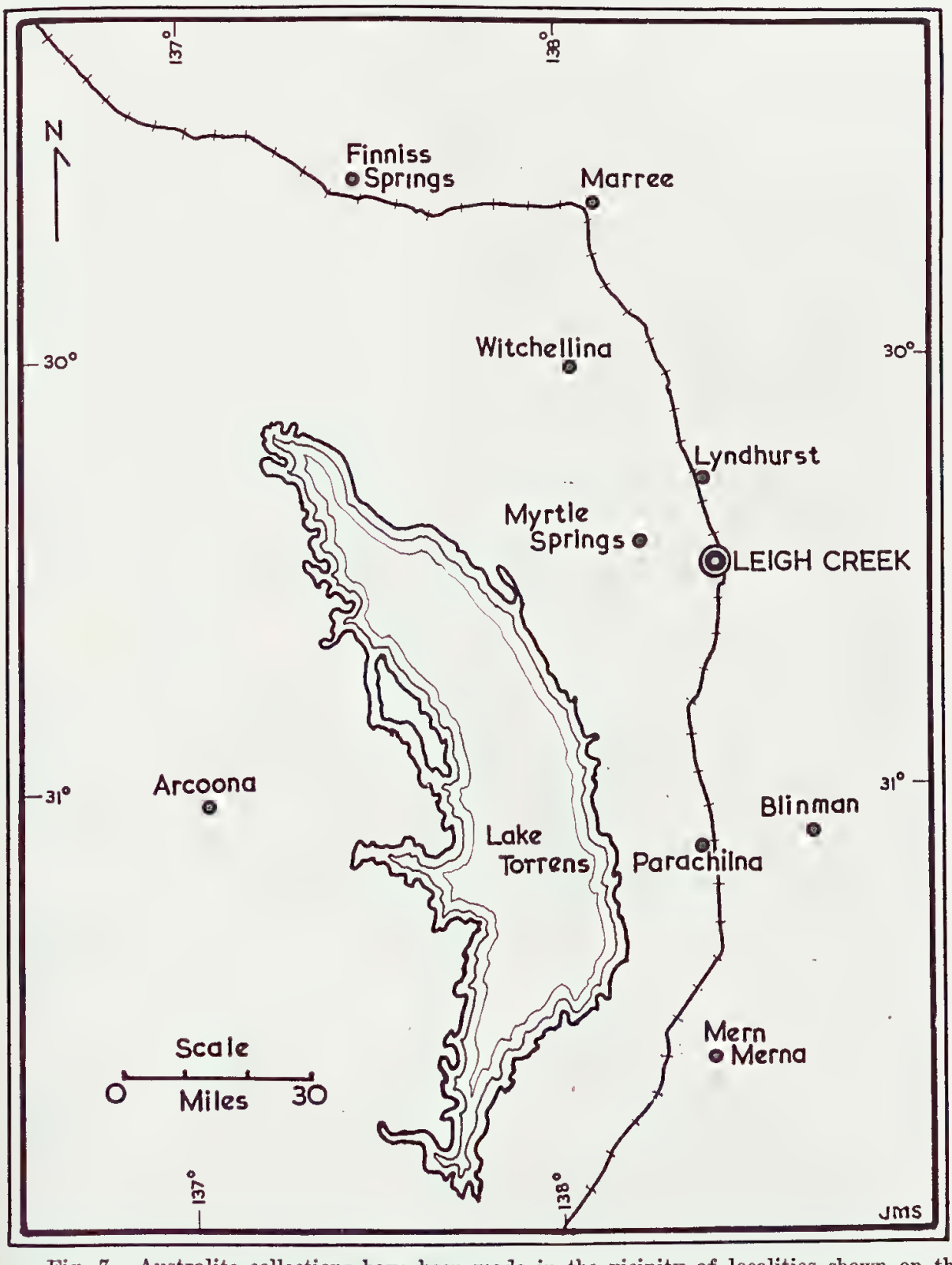


Fig. 7. Australite collections have been made in the vicinity of localities shown on the map. In the case of Lyndhurst, Blinman and Mern Merna only single specimens are known.

DISCUSSION

A comparison has been made between the Myrtle Springs australites and those from adjacent areas represented in the South Australian Museum collection (see fig. 7). The largest group is from the Marree-Finniss Springs-Lake Harry region, a total of some 500 specimens. Only two flanged forms occur in this number, a complete flanged button from east of Lake Eyre, and a broken flanged button from Lake Harry. All other specimens are medium to large, flangeless and highly abraded. Lens cores, boats and dumbbells predominate.

Few australites have been recorded from the Flinders Ranges because of the rugged nature of the terrain where vigorous erosion and unstable slopes effectively mask any falls. Finds can therefore be considered fortuitous and there are only three specimens in the Museum collection. These are three well-preserved flanged buttons from Lyndhurst, Blinman and Mern-Merna. Details of the occurrence of these specimens are not known, but the degree of preservation and the general localities of the specimens suggest links with the Myrtle Springs group. It may be that they were collected on the Torrens plain. Australites have recently been reported from the Motpena region of the plain west of Parachilna (N. Bartlett, verb. comm.), an area previously unrecorded, and these show a similar degree of preservation to those from Myrtle Springs, and probably indicate a southward extension of this strewn-field.

Collections are also known to have been made in the Witchelina area to the north of Myrtle Springs, and near Arcoona to the west of Lake Torrens. The absence of australites along the eastern shore of the lake suggests that the Arcoona group may belong to a separate strewn-field, but the Witchelina group forms a link between Myrtle Springs and the Marree area. It would seem therefore that the Marree, Witchelina, Myrtle Springs and Motpena australites all form part of one extensive strewn-field with a possible limit to the south-west along the eastern shore of Lake Torrens, but with no definite boundaries to the north or south-east.

Population variations are to be expected in an area of this size, and there is a striking difference in weight between the populations from Myrtle Springs and Marree. Little statistical work has been carried out on the australites from the Marree area, but the average weight per specimen exceeds 5 gm. in contrast to the Myrtle Springs average of 1.25 gm. The heaviest specimens from the Marree area are two dumbbells weighing 88 gm. and 50 gm. compared with the maximum weight for a core of 11.18 gm. from Myrtle Springs. From measurements made on a small group of 38 australites from Marree

by Dr. D. R. Chapman* (pers. comm.), the modal density of 2.40 corresponds to that obtained for the Myrtle Springs collection here described.

Mention has already been made of the limitations imposed on the study of many existing collections of australites by the insufficient data accompanying them. These inadequacies are thrown into relief when comparisons are made with a systematic collection such as that from Myrtle Springs. The fact that in a relatively small area of some 100 square miles the collection contained examples of all the major australite shape types, leads to the assumption that an assemblage of this type could be expected in other areas also. The Myrtle Springs collection is in effect a natural assemblage representing the original population of the area, and such an assemblage can be predicted to occur elsewhere within the Australian strewn-field. Deficiencies in many existing collections are therefore primarily due to haphazard, unsystematic collecting, which has resulted in an unrepresentative and therefore misleading assemblage.

The limitations imposed by unsystematic collecting have been increased in certain areas where the australites have suffered appreciable weathering since fall. In these areas the original population has already been modified to some extent by the destruction of small forms.

It is important that particular care should be taken when making collections of australites to ensure that all the information relating to the occurrence be documented. This can only be achieved by the systematic working over of an australite-bearing area. Our knowledge of the geological occurrence of australites and their distribution over the Australian continent is, with the exception of a small number of areas, extremely scanty. It is only by careful recording of any new australite localities and by the re-survey of some of the more rewarding of the collecting areas of the past, that we will be able to assess the true distribution and the variation in australite populations over the continent.

ACKNOWLEDGMENTS

The author wishes to thank Mr. N. B. Tindale, then Senior Curator of Anthropology at the South Australian Museum, and Mr. H. Mincham, Information Officer, for their part in the collection of the Myrtle Springs australites. Mr. Tindale's knowledge of the culture succession of the Australian aborigines and of their stone implements was of considerable value in the field, and his assistance and interest in the project is gratefully acknowledged. Thanks are also due to Mr. H. M. Cooper, Honorary Associate in Anthropology, for his helpful discussion of archaeological matters.

* Staff Scientist, National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California.

Dr. D. R. Chapman, of the National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California, kindly allowed me to make use of his unpublished data on australites from Marree.

Professor Kunihiko Kigoshi, of Gakushuin University, Tokyo, made available the radiocarbon date on charcoal from the native hearth near Pine Dam, which is quoted in this paper.

Finally, the author wishes to thank Dr. B. Daily, of the University of Adelaide, for his critical reading of the manuscript.

REFERENCES

Baker, G., 1956: Nirranda Strewnfield Australites, South-East of Warrnambool, Western Victoria. Mem. nat. Mus. Victoria, 20: 59-172.

———— 1960: Origin of Tektites. Nature, 185 No. 4709: 291-294.

———— 1963: Form and Sculpture in Tektites, in *Tektites* (Ed. J. A. O'Keefe) University of Chicago Press, Chicago.

Fenner, C., 1934: Australites, Part 1. Classification of the W. H. C. Shaw Collection. Trans. Roy. Soc. S. Aust., 58: 62-79.

Gill, E. D., 1965: Quaternary Geology, Radiocarbon Datings and the Age of Australites. Geol. Soc. America, Spec. Paper 84.

Mawson, D., 1958: Australites in the vicinity of Florieton, South Australia. Trans. Roy. Soc. S. Aust., 81: 161-163.

Mulvaney, D. J., 1960: Archaeological Excavations at Fromm's Landing on the Lower Murray River, South Australia. Proc. Roy. Soc. Vic., 72(2): 53-85.

Tindale, N. B., 1957: Culture Succession in South Eastern Australia from Late Pleistocene to the Present. Rec. S. Aust. Mus., 13(1): 1-49.

SHORT NOTES

CERCARTETUS LEPIDUS (THOMAS) AN ADDITION TO THE FAUNA OF KANGAROO ISLAND

On the 17th of November 1964, Mrs. I. S. Davis of Brookland Park, Kangaroo Island, captured a juvenile male of the Little Tasmanian Pigmy-possum, *Cercartetus lepidus* (Thomas) 1888. The animal was taken while escaping from the fire during "burning off" operations, approximately 8 miles north-west of Karatta, on the northern boundary of section 4, Hundred of Ritchie, Kangaroo Island, South Australia. On the 20th of November 1964, the Pigmy-possum was forwarded to Mr. C. R. Tidemann of Millswood, South Australia, who kept it in captivity until its death on the 29th of December, 1965. Mr. Tidemann subsequently presented the specimen to the South Australian Museum, as a prepared skin and skull in excellent condition. It has since been incorporated in the Museum's mammal collection, registration number—M6338.

The pelage colouration is exactly as in the original description of the species (Thomas 1888). Cranial details are set out in table 1. All measurements are in millimetres, taken under a microscope with modified Helios calipers. The terminology, unless otherwise stated, is after Cockrum (1955).

TABLE 1

	C. lepidus adult ♂
Basal length	17.0
Occipitonasal length	19.4
Zygomatic breadth	11.9
Cranial breadth*	10.2
Interorbital breadth	4.0
Maxillary breadth at M^2	6.0
Depth of cranium	8.2
Palatal length	9.9
Length of incisive foramina	1.3
Length of tympanic bulla	4.0
Length of nasals	7.7
Width of nasals	2.7
Length of mandible	11.8
Crown length of maxillary molar series (M^{1-4})	3.0
Crown height of P_4	0.9

This specimen constitutes the first living record of *Cercartetus lepidus* to be taken outside Tasmania. Two other records both from the Australian mainland, are confined to fossil and sub-fossil deposits.

* Measured between the squamosal bones, immediately dorsal to the zygomatic processes.

These are Ride (1960), in cemented limestone breccia of probable Upper Pleistocene age, from Wombeyan, New South Wales, and Wakefield (1960), in a sub-fossil deposit at the Pyramids, near Buchan, Victoria. Ride (1960) attributes the decline of *C. lepidus* on the mainland to a progressive change in environmental conditions, resulting from increasing aridity. Wakefield (1963), suggests a link between the decline of *C. lepidus* in the Buchan area and a change in vegetation from wet sclerophyll forest to dry sclerophyll forest. It is interesting to note therefore, that the locality on Kangaroo Island from which the present specimen was obtained, is situated in an area of 32 inch annual rainfall, calculated over the past 10 years, when seasons have been particularly good. Neighbouring areas within a radius of 12 miles, record averages of between 22 inches and 26 inches, calculated over 40 years or more. In addition to this the vegetation type comprises one of the driest sclerophyll communities found in South Australia. Namely, the *Eucalyptus cosmophylla-Eucalyptus baxteri* scrub, as described by Wood (1937).

PETER F. AITKEN.

LITERATURE CITED

Cockrum, E. L., 1955: *Manual of Mammalogy.*

Ride, W. D. L., 1960: The fossil mammalian fauna of the *Burramys parvus* breccia from Wombeyan Caves, New South Wales. Journ. Roy Soc. W. Aust., 43(3): 74-80.

Thomas, O., 1888: Catalogue of the Marsupialia and Monotremata in the collections of the British Museum (Natural History). British Museum, London.

Wakefield, N. A., 1960: Recent mammal bones in the Buchan district—2. Vict. Nat., 77(8): 227-240.

———— 1963: The Australian Pigmy-possums. Vict. Nat., 80(4): 99-116.

Wood, J. G., 1937: *The Vegetation of South Australia.*

DISTRIBUTION AND FORMS OF ZOSTEROPS IN SOUTH AUSTRALIA

It is now generally agreed that only one variable species, *Zosterops lateralis* (Latham), Greybacked Silvereye, is to be found in temperate Australia (Keast, *Gould League Notes* (N.S.W.), May, 1958).

Recent collecting has indicated that at least three races should be listed for South Australia. The first of these is *Z.l.halmaturina* Campbell, which is very common in the wetter parts and occurs in decreasing numbers in the drier areas. There are old records of its presence beyond Cowell and Kimba on Eyre Peninsula and more recent reports from the Flinders Ranges at Buckaringa Gorge (1961) and Wilpena Pound (P. Haselgrove, sight obs.—September, 1965). Specimens were taken by the late W. D. K. MacGillivray, at Broken Hill, New South Wales, in June, 1920. In the south-east, it is present in the Mount Gambier district.

Latest information indicates that *halmaturina* ranges in the west at least to Sceale Bay, just south of Streaky Bay (specimens—October, 1963) and perhaps to Murat Bay, near Ceduna, as given by Terrill and Rix (*S.A. Orn.*, 20: 59). Beyond this point it is replaced by *Z.l.gouldi* Bonaparte, the so-called Western Silvereye, specimens of which have been obtained, "in low scrub", near Nullarbor Station, close to the Head of the Bight (1963) and at a place above Eucla, near the Western Australian border (J. R. Ford, pers. comm., 1966).

The Western Silvereye, which resembles *halmaturina* in size and general coloration, is, nevertheless, readily distinguished in the skin by its all-green back, dull fawn flanks and bright yellow coloration on the throat and under tail coverts.

On the other hand, the characters of *halmaturina* are less easily defined, but, as pointed out by Kikkawa (*Emu*, 63: 32-33) some of the variation is due to sex, with males being darker on the flanks and, usually, with more yellow on the throat. As a rule, the throat is drab grey and the flanks light greyish olive in most females, whereas in males the throat is dull olive yellow, not sharply demarcated from the grey breast as in some eastern Australian birds, and the flanks are various shades of buffy brown, never deep rufous. Specimens from littoral Eyre Peninsula, Flinders, Reevesby and Kangaroo Islands are known with a greenish wash on the back, which seems to indicate gene-flow with *gouldi*. As might be expected, similar birds have been taken on the foot of Yorke Peninsula (January, 1966), but I do not think the name *flindersensis* Ashby (Emu, 25: 117) should be applied

to what appears to be an intermediate "step" between *gouldi* and *halmaturina*. The latter, as suggested above, is a very variable form and *flindersensis* is, perhaps, best included within it.

Now in eastern Australia, there is increasing evidence that, in local populations, the often marked seasonal variation in plumage coloration cannot be attributed to age or sex and must be due to the presence of nomadic foraging flocks or long distance migrants (Keast, *loc. cit.*; Lane, *Bird Bander* [N.S.W.], (1(2): 11-12). Mack (*Emu*, 31: 290), who was unaware of any regular movements within the species, rejected all described forms. However, there is little doubt that the birds of eastern Australia and Tasmania are nearly always more brightly coloured than those in South Australia—the flanks are either rufous or brownish (but grey around Sydney) and the throat whitish (Tasmania) or, more often, yellowish.

The occasional observation of dark-flanked individuals in flocks around Adelaide and the Mount Lofty Ranges in autumn has given rise to the hope that proof will be forthcoming that these more highly-coloured birds are visitors from the east; but, so far, there is no evidence of this. However, it has been established by C. K. Pawsey, of Kalangadoo, that brown-flanked, or "Tasmanian type" birds visit the south-east, where two males were collected near Mount Gambier in February, 1966. One bird was yellow-throated and perhaps referable to the southern Victorian breeding population, whilst the other was white-throated and a typical Tasmanian example. These specimens represent the first recorded occurrence in South Australia of a third, non-breeding subspecies which Keast (*loc. cit.*) has defined under the name *tasmanica* Mathews. If the type locality of the nominate form is "Tasmania" rather than "New South Wales" (as generally quoted), then *tasmanica* would become a synonym of it.

H. T. CONDON.

SURPRISING CAPTURE OF QUAIL-THRUSH BY BARN OWL

On 4th September, 1966, Master Gilbert Pfitzner found a dead Barn Owl, *Tyto alba* Scopoli, on the Port Wakefield Road, near the Light River. On skinning the owl he found the head, complete with feathers, of a small passerine lodged in the intestine. Cause of death of the owl is unknown. It has been possible to identify the passerine as a young male (with black and white throat) of the Spotted Quail-Thrush, *Cinclosoma punctatum* (Shaw), a rather secretive, ground-dwelling species that lives in open forest country in the Mount Lofty Ranges, perhaps 10 or 15 miles away.

H. T. CONDON.

A FURTHER DESCRIPTION OF LARGE STONE IMPLEMENTS FROM SOUTH AUSTRALIA

By H. M. COOPER*

SUMMARY

This paper refers to some stone implement types found upon certain former native camping grounds in South Australia.

The figured specimens are discussed in detail and a description is given of the two principal sites upon which they were found.

Details of a more generalized nature, but relevant to the subject matter in this paper, are also discussed but no attempt has been made to estimate the age or possible uses of the implements with the exception, here and there, of a few remarks of an explanatory character.

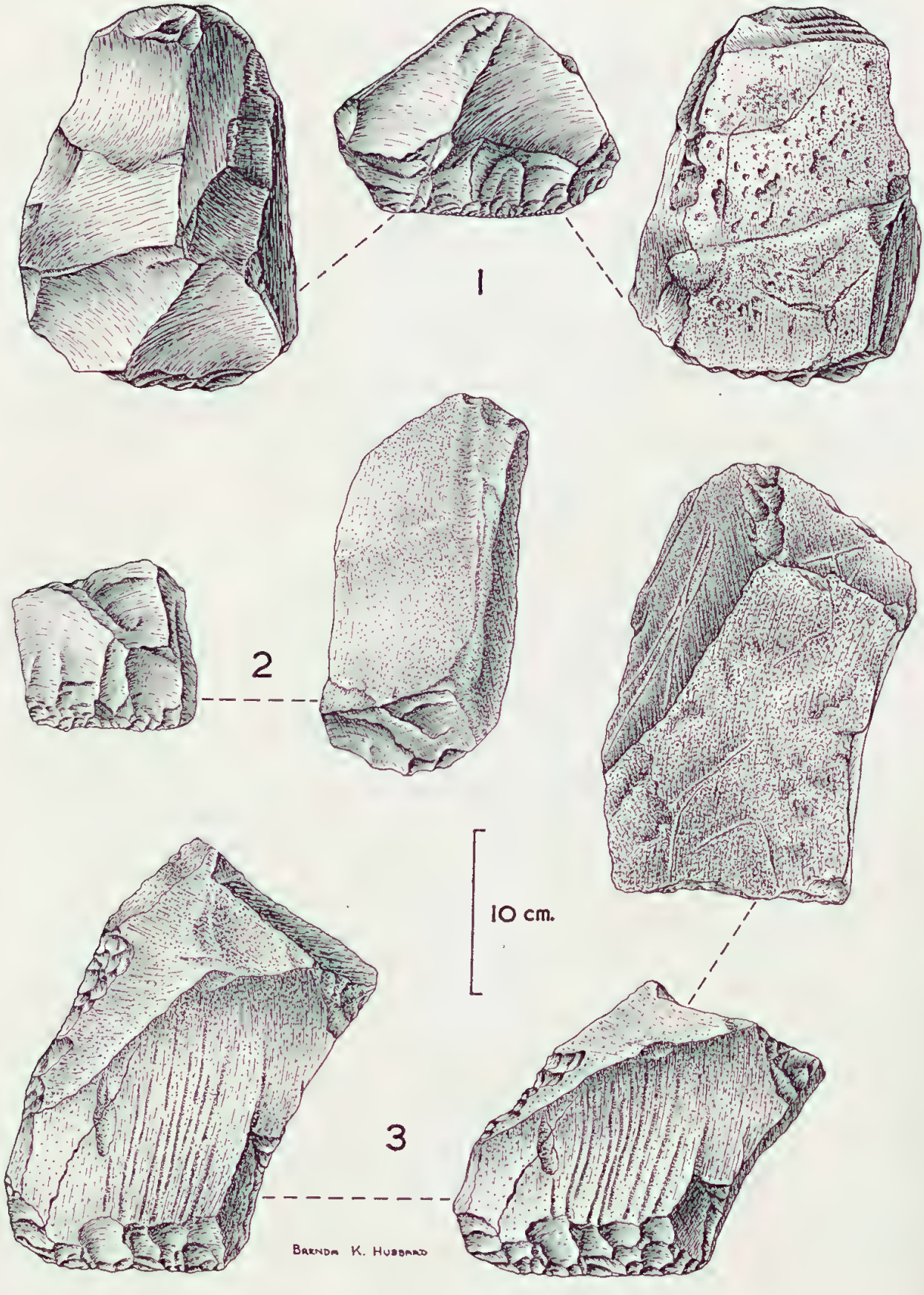
THE TWO PRINCIPAL SITES

Hallett Cove

A somewhat detailed description of the topography of the Hallett Cove site was referred to by Cooper (1959), but briefly, it is an ideal one—loamy soil (now cultivated), sloping gradually inland from the coastal cliffs and about 220 feet above sea level. A deep gully, with a permanent spring, adjoins its southern side. There are unobstructed views in all directions.

The practical value of many repetition visits to any one native camping ground may appear to be dubious and unnecessary if the examinations are merely the continuity of a casual or perfunctory nature. It became apparent however, that the correct evaluation of any camp-site with such a wealth of large type material of various sorts, shapes and sizes, as at Hallett Cove, could not possibly be made during the course of a few visits, however carefully they were carried out. Further and more frequent examinations of a more critical nature were then made, of the large amount of material still remaining at that time upon the site. This locality, shortly to be subdivided, is now practically devoid of material. The collection of over 1,700 large implements from the main camp and its two small adjoining subsidiaries, made in the course of 200 visits spread over a period of 30 years, has proved to be of great assistance in at least one avenue of research, namely, that several types, primitive and elementary in design and previously rejected, passed by unnoticed or considered doubtful were, in fact, genuine types. There is nothing more valuable to assist in establishing the validity of any one particular type, deemed to be dubious, than the ability to produce a considerable number of similar repetitive specimens which the numerous visits made possible.

* Honorary Associate in Anthropology, South Australian Museum



FIGS. 1-3.

It was instructive, also, to examine blocks struck open and discarded by the native workmen owing to breakages or faulty primary flaking, and others rejected because of the inferiority of material exposed after they had been broken.

A very interesting implement, found upon the Hallett Cove camp-site (not figured) had been prepared from a block of rather compact Travertine Limestone. It possesses a circular base with the equivalent of stepped trimming all around it with the exception of a small portion which appears, rather indistinctly, as the bulb of percussion. It is of "Horsehoof" design and the trimming is very good considering the inferior type of stone used. The base is 4 inches in diameter and as flat as the texture of the material used would permit. The implement, although core-like, is really a bulky flake. It is, of course, impossible to determine its use.

It was noticed when searching the Hallett Cove site for implements that they often occurred in patches (with barren ground intervening) as if to indicate that they represented the former sites of Wurlies. The ground is so flat or slightly undulating that they were probably still *in situ*.

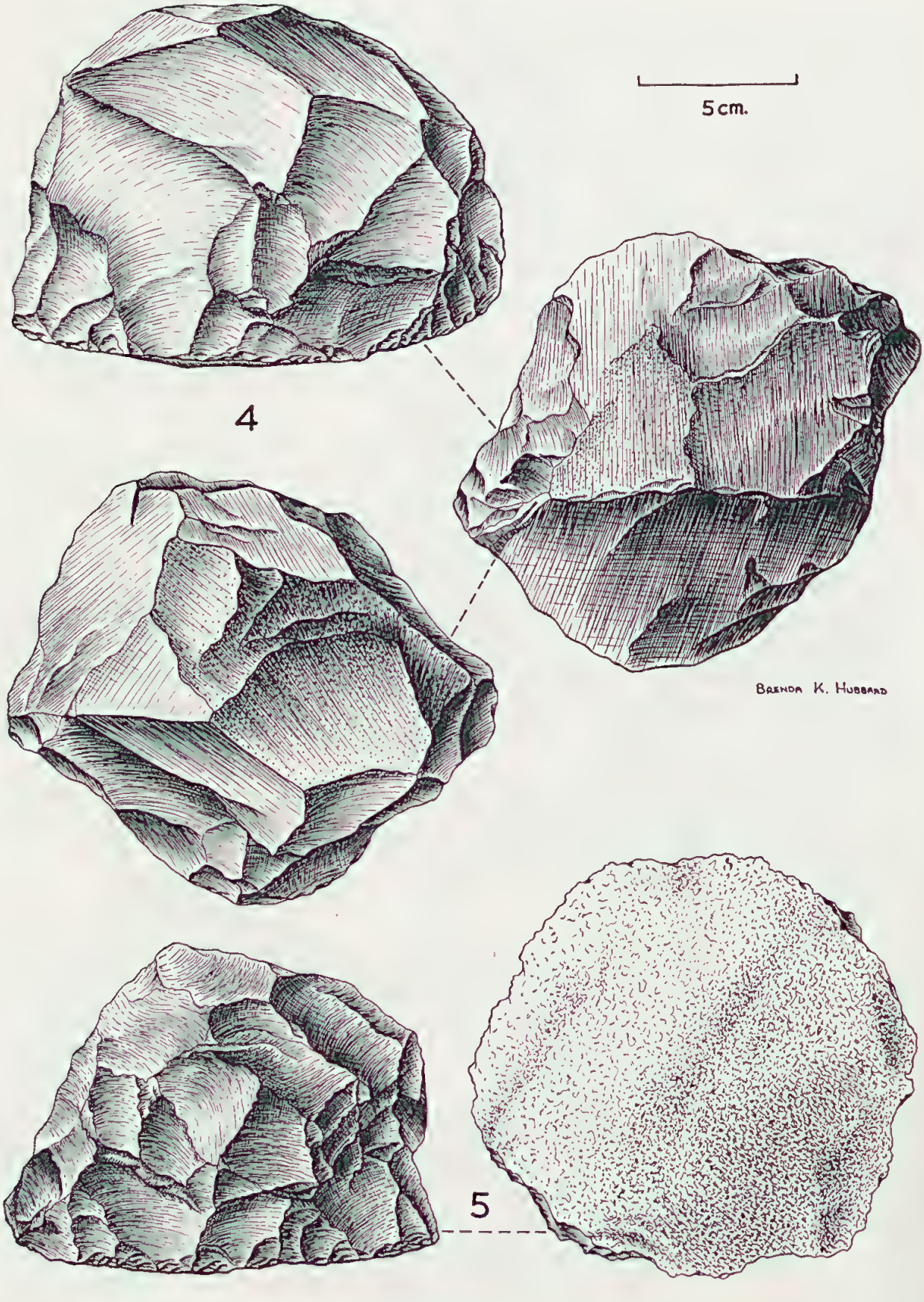
A sprinkling of small fresh-looking trimmed flakes, attributed to recent cultures, occur upon the site in the shape of end scrapers, saws and adzes. Pirri, geometric and other microlith types are absent although they occur plentifully upon adjacent camp-sites on the plains and along the coastal regions. This may indicate that at some period or periods the camping ground may have been unattractive owing to adverse climatic or other reasons.

Worn implements of the large types were relatively common upon the site and some, probably highly prized, to such an extent that their useful life could no longer be prolonged by further treatment.

Melrose

The figured specimens marked Melrose were found upon an extensive native camp-site which extends along the banks of Willochra (formerly Mount Remarkable) Creek, with considerable breaks here and there, from a point where it leaves the ranges at Melrose and thence on to the adjoining plains.

Thousands of water-worn pebbles and blocks, apparently carried down and deposited by the creek during earlier periods of higher rainfall, litter the ground (in places for a distance of half a mile in width). Some of the short creeks, which drain the ridges and gullies of the eastern side of Mount Remarkable, have added their quota to this accumulation, while others, which fail to reach the Willochra, spread out and the rocks which they have carried down, are distributed in the form of small scree-like masses.



FIGS. 4-5.

Most of the pebbles and angular blocks consist of country quartzites, chiefly coarse-grained. There is a sprinkling of tillite, also in the form of blocks and pebbles. They appear to have been derived from an exposure of that rock on the south-west side of the mountain.

The implements themselves are scattered widely but are not numerous and they become scarcer as the distance from the creek is increased. Collecting on a camp-site of this nature is necessarily a slow and tedious process but numerous visits assisted in covering practically all the area, 200 large implements being collected.

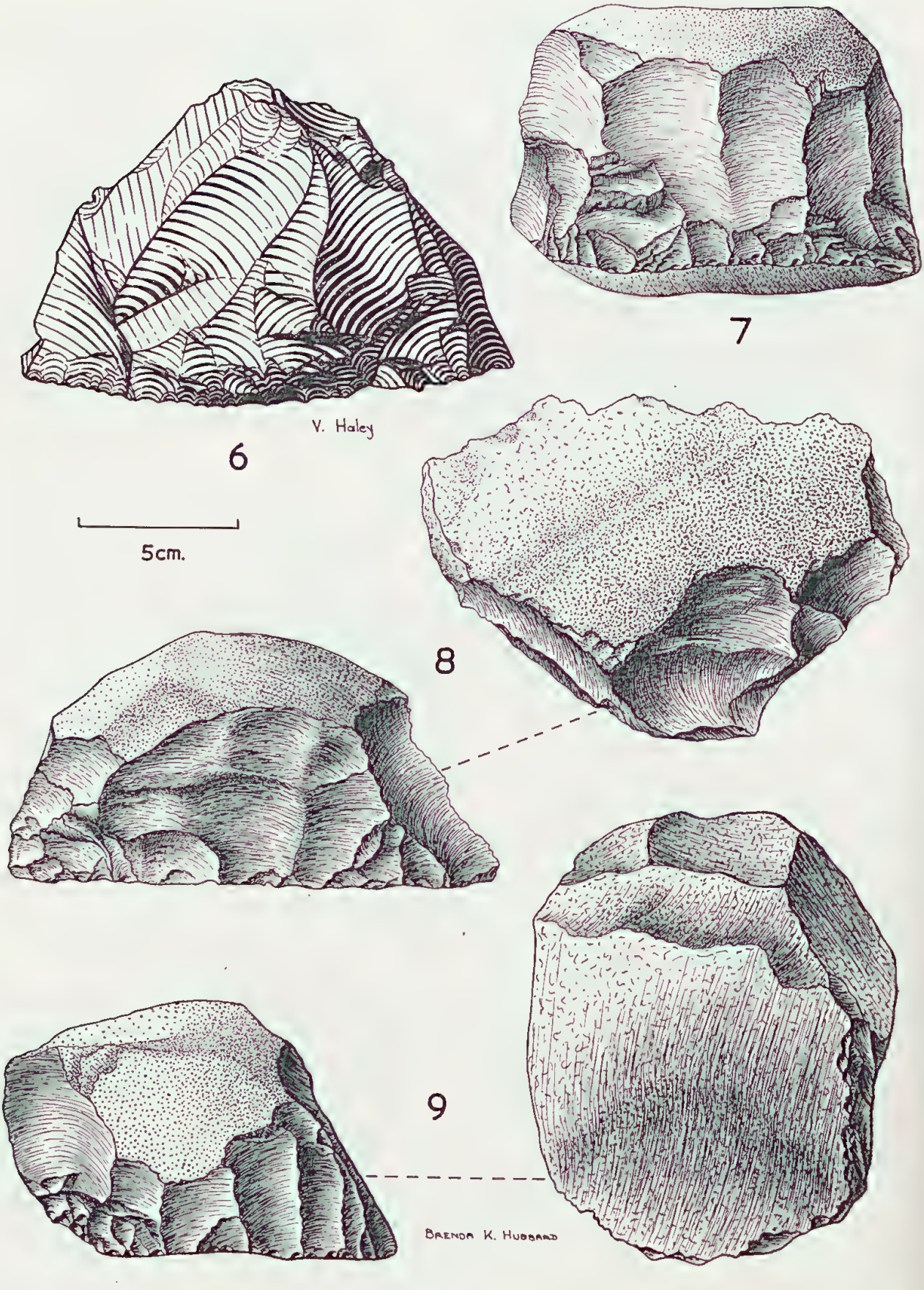
The existence of so many specimens often partly or completely worn down by use, proves that the site was a permanent one and not a workshop. The population of the camping ground, considering its extent and the limited number of implements found upon it, appears to have been small. The quantity of waste and discarded flakes was surprisingly low but appears to be mostly due to the minimum of flaking needed to shape the implements, which are mostly simple in design. An interesting feature of the area was the discovery, in a nearby field of a faintly discernible shallow depression with pebbles deposited upon its surface. Its course was traced towards the Willochra indicating that it was the bed of a former watercourse, since silted up. It yielded a series of large implements.

The main camp-site is ideal, being flat, above flood level, with the Willochra Creek flowing through it. The creek flows strongly, often in flood, during the winter months.

The absence of conventional well-used hammer-stones appears to be directly associated with the vast number of angular and water-worn blocks lying so conveniently upon the surface of the camping ground. An occasional stone was noticed, here and there, with a few pitmarks upon its surface, suggesting its employment and then rejection, as a hammer-stone in shaping another block of appropriate proportions, similarly picked up nearby, into a large simply trimmed implement. Identical features had been noticed upon other stony sites, such as referred to by Cooper (1961).

The almost total absence of small trimmed implements, soon apparent, was explained by the non-existence of hammer-stones which are essential in strictly controlling the correct removal of flakes in the preparation of smaller types. This is a problem which does not arise during the shaping of large simply designed implements.

No signs were seen of permanent camping grounds during many ascents of the rugged ranges nearby, such areas, as elsewhere, being mainly reserved for brief hunting and food-gathering expeditions. A small group of large implements was found, however, upon a flat at the edge of the foothills overlooking the plains. Two others, roughly made and lying upon



FIGS. 6-9.

the surface alongside one another were discovered merely by chance, upon the mountain side, at about 1,700 feet where a stop was made to examine some vegetation at the same spot. It appeared likely that these two implements had been improvised from blocks, scattered liberally upon the spot, used for some casual need which had arisen during a hunting expedition, and then discarded.

A somewhat hasty examination was made of the interior earthy floors of several large hollow specimens of *Eucalyptus camaldulensis* (Red Gum) while collecting upon the Melrose site nearby and a well-defined lower millstone, with peck marks, was found in one at a depth of about 3 inches. A similar but more systematic search of other large trees elsewhere, especially adjoining camp-sites or permanent water-courses, may yield interesting material because such places provided the natives with shelter during rainy, cold and other adverse climatic conditions.

The Wepowie site, briefly, comprises gently rising loamy soil adjoining a dry water-course which, with a few other small streams, combine to form the Wepowie Creek in which there is permanent water. The site is located in the Narrien Hills in undulating country near Orroroo. Its height above sea level (estimated) is about 1,800 feet.

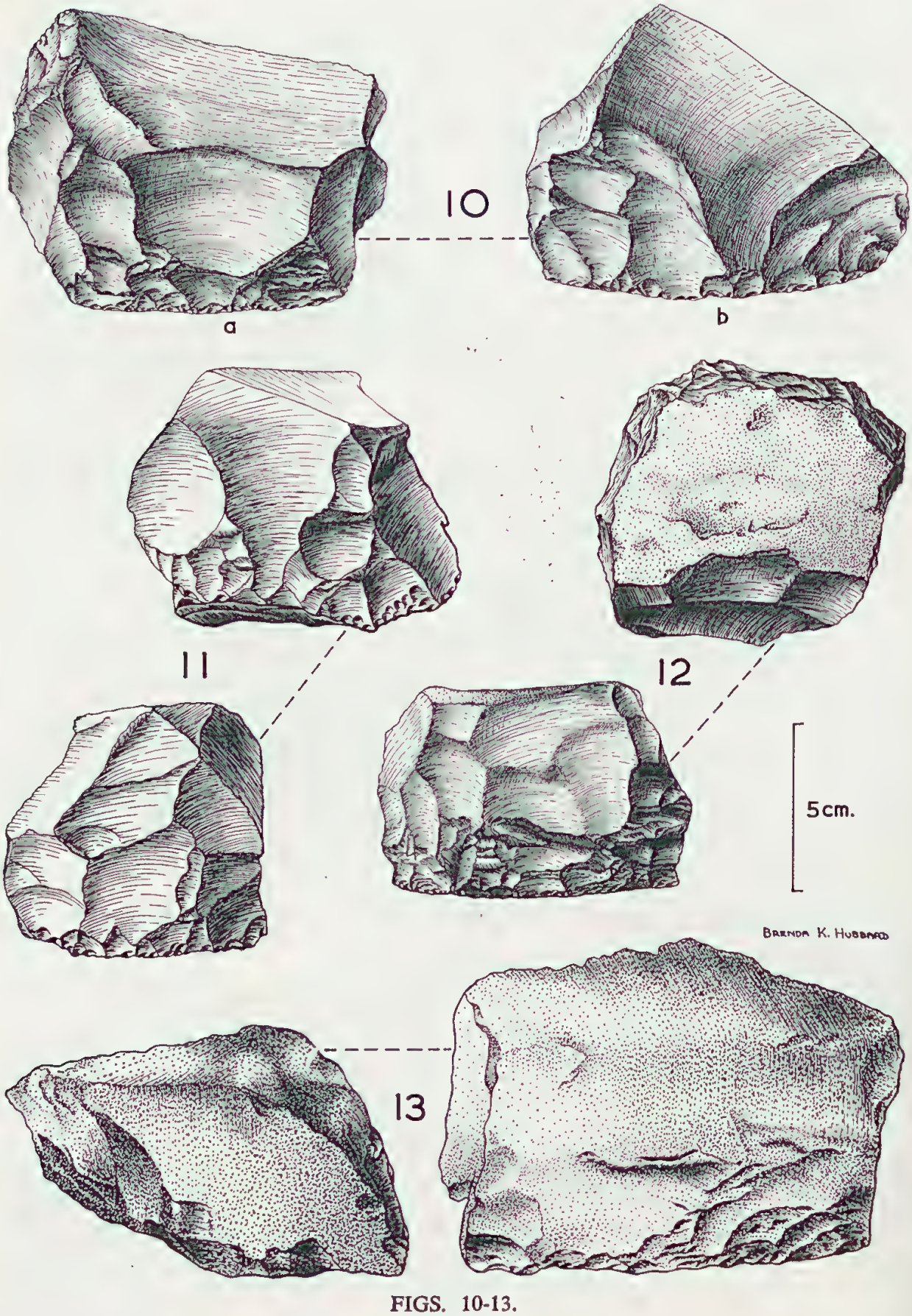
The South Hummocks site, also briefly, comprises fields of loamy soil which slope gently downwards from the foot of the South Hummocks towards the sea. The site is intersected by several dry watercourses which, when running, consist of streams along beds which appear very small compared with the distance between their banks; this suggests that they were formerly more considerable streams. The implements, not plentiful, occur near the banks of the water-courses. Height above sea level (estimated) about 250 feet.

GENERALIZED DISCUSSION

Quality of Rock Available

Brief reference has been made to the rough finish applied to certain of our stone implement types in some areas compared with the excellent work apparent on those of similar nature in other localities. This appears to be closely related to the quality of the local rock available (but not including traded and transported material).

The skill of the native workman, who by force of circumstances had no more than tough fine-grained quartzite, milky vein quartz and other intractable rocks at his disposal, was probably of as high an order as the maker of the beautifully finished pirri, geometrics and other microliths of Far Northern South Australia.



FIGS. 10-13.

The type of rock available also appears to have some bearing upon the types of implements constructed, especially those of large size. No example of the widely distributed "Horsehoof" trimmed core type has been reported from the South-East of South Australia where flint is readily available over large surface areas and small implements, derived from it, occur in thousands.

Flint fractures easily and is extremely brittle and to retain an efficient work edge, for even a small space of time on an implement type of this nature, would virtually be impossible. This may explain the reason for its apparent non-existence in that area.

A somewhat similar situation occurs on Kangaroo Island where the conventional large stone implements of its former unidentified population were hand choppers made from hard fine-grained quartzite of which several thousand have been collected. Water-worn nodules and pebbles of flint occur in places along the shore, intermingled with those of quartzite (referred to above), which are notably resistant to wear as indicated upon the surfaces of those converted into pebble choppers.

As far as it is officially known, however, there is no evidence of a pebble chopper, made of flint, having been found there.

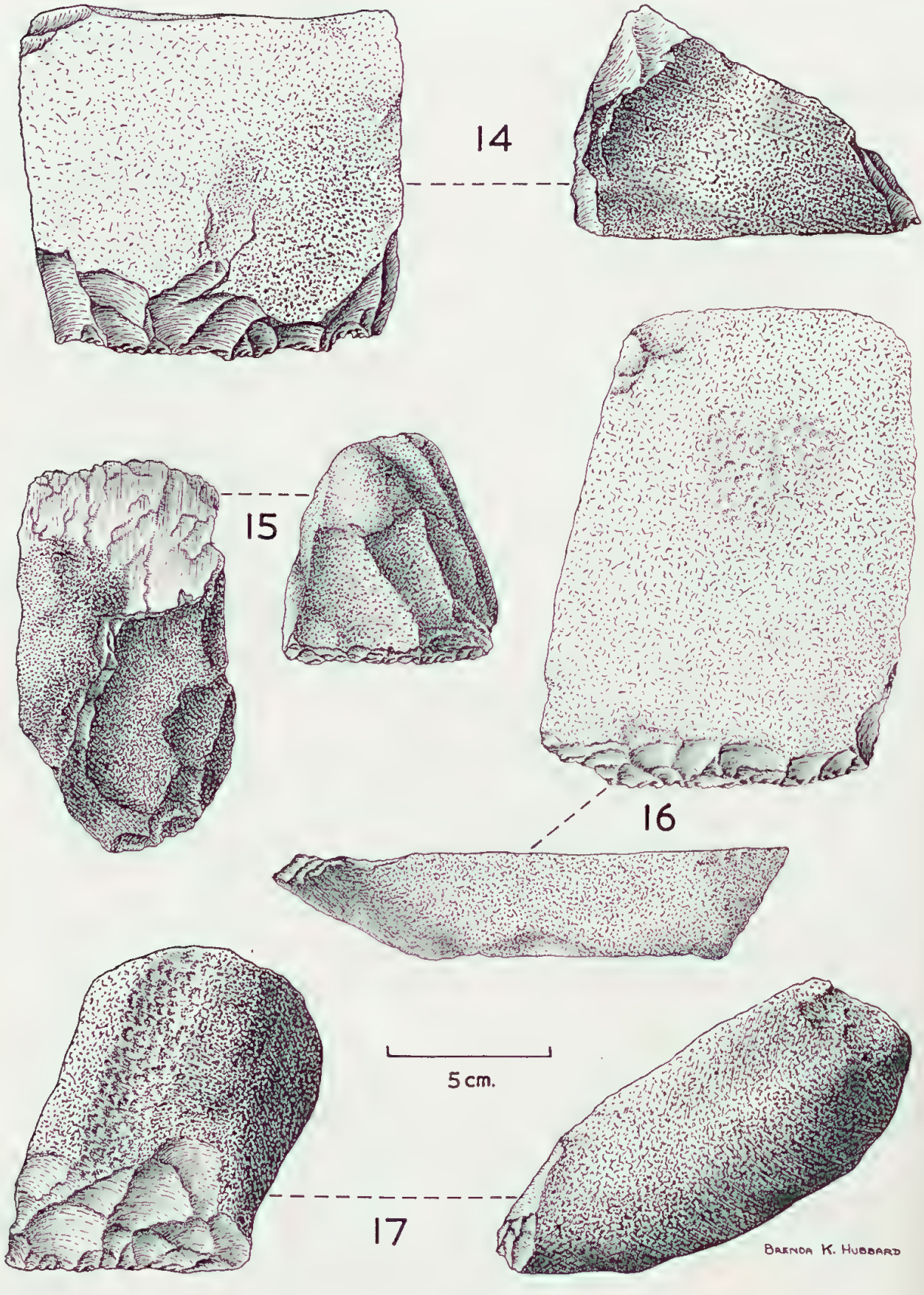
Here again the brittle nature of this material may have proved to be unsuitable for use in the construction of pebble choppers, the working edges of which were subjected to considerable stress and strain.

An interesting situation was found to have existed at Cape Hart, Kangaroo Island, Cooper (1948), where quartzite and flint pebbles lie intermingled upon the beach. Two distinct and separated camp sites existed here, one belonging to the extinct islanders, in association with their quartzite pebble choppers and the other the site of a party of European sealers and Tasmanian native women accompanying them, of the early 1800's. This site yielded small implements of Tasmanian type and discarded flakes and cores, all made of flint secured from the beach below. A careful search failed to reveal the presence of a single implement of quartzite.

This site, which includes small glass and iron debris, dates from early historical times and is confirmable.

Flake Making Core and Trimmed Core Implements

The classification of this material, which has not been thoroughly examined by the writer, may be more involved than it appears to be. The two main types (1) deliberately trimmed implements and (2) those employed to provide suitable flakes for the production of flake implements, are fairly easy to classify; (1) by the primary and secondary trimming



FIGS. 14-17.

which has been applied to them and those in type (2) by their lack of secondary trimming and their shape (which often indicates by the form of the flakes removed), the type of small implements which it was intended to create, such as long end scrapers, discoidal adze stones, microliths and others.

There remains, however, a considerable intermediate group which possess "secondary" trimming of a more or less dubious kind around all or on a portion of their bases, sometimes quite symmetrical, and the difficulty here is to determine whether this is, in fact, intentional.

It appears that this may be possibly due to the repetition of ineffectual blows to remove suitable flakes, especially from blocks of hard, intractable material which may cause bruising and pseudo secondary trimming, and even in some cases, stepped trimming.

This flaking seems to possess a subtle and almost indefinable variation when compared with deliberate trimming but the above impression is somewhat speculative and needs further and more intensive search.

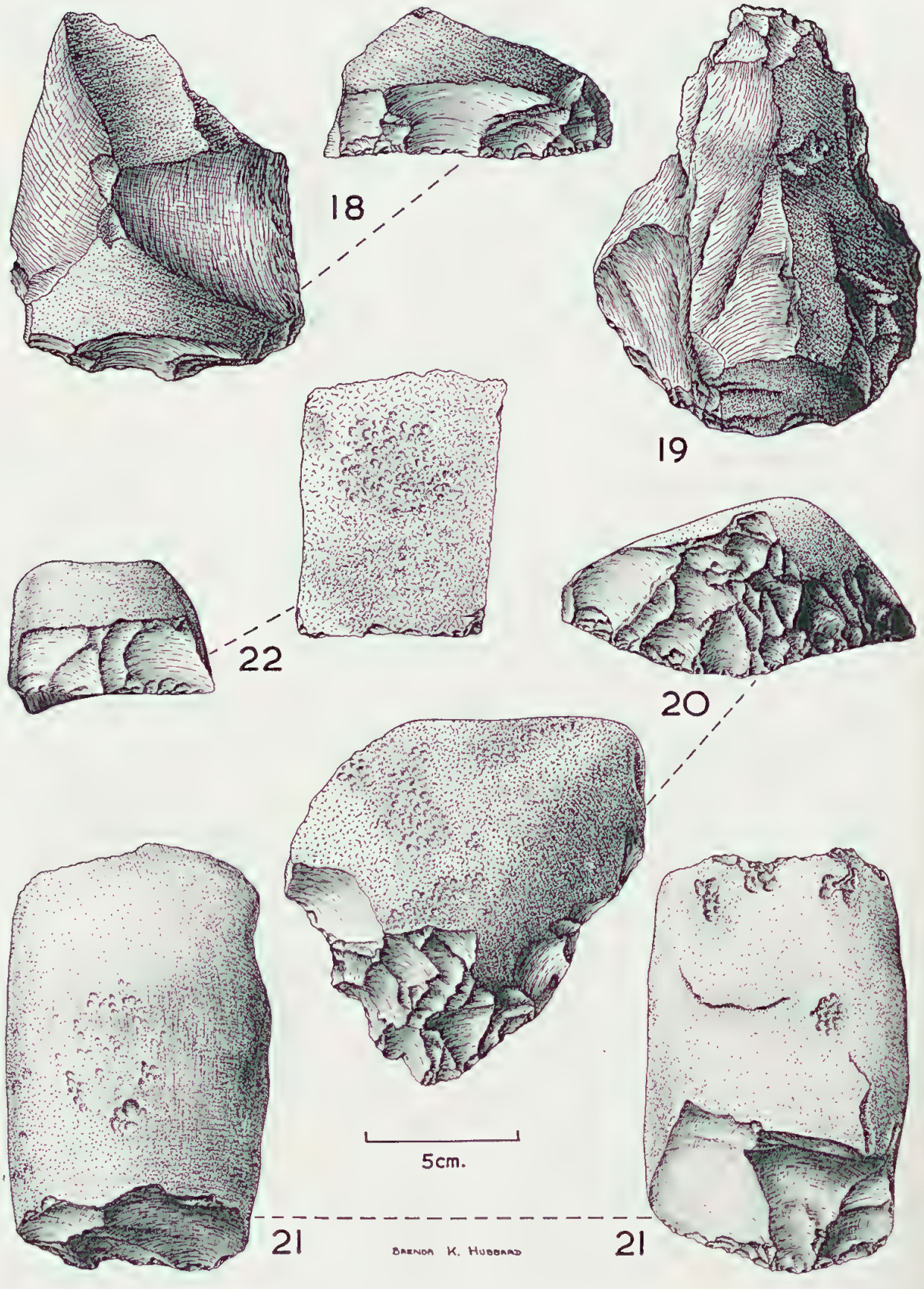
"Horsehoof" Type Core Implements

Two early references to implements somewhat similar to Australian "Horsehoof" type trimmed implements may be of interest.

(1) Gillespie (1877) refers to certain types commonly called "Hoof" Cores, found in England and France, and considered by him to be trimmed core implements and not flake making cores, as at that time they were thought to be. One specimen was figured by him but size is not given. This is certainly "Hoof" or "Horsehoof" in shape but if it is representative of others examined by him the scanty trimming around its base hardly justifies its identity as a trimmed "Horsehoof" implement, at least judged by Australian standards. In addition, the long narrow flakes apparently struck from it, especially if repeated upon the other specimens, may indicate that they were intended for conversion into trimmed blades such as knives or saws in which case it would represent a flake-making core.

(2) Holmes (1895) states that implements (sketches of which resemble Australian "Horsehoof" trimmed cores), were discovered in considerable numbers in the cultivated fields around Mitla. They were also seen mixed with the mortar used in forming the walls and pyramids of the great buildings of that city. Some of the implements had edges greatly worn and battered.

It appeared, he continues, that they had been added to the earthy adobe material in order to strengthen it but whether they belonged to the actual builders of the great walls and pyramids or had been left by a previous people, in the fields, it was difficult to determine. Holmes' description has already been referred to by Cooper (1961).



FIGS. 18-22.

These references, although lacking in details are nevertheless, interesting.

Surface Finds

The value of loose finds upon surface camping grounds is modified because it cannot include material *in situ* which is of considerable significance. The implements collected, however, do represent, at least, the stone material cultures of the native peoples who successively camped upon them.

Australian topography, unfortunately, does not lend itself kindly to stratification in vast areas, including the arid plains and although recent important finds in rock shelters and also around certain lagoons, swamps and other places have filled in many gaps, it appears that dependance upon surface finds in others will still be of considerable value, at least in the immediate future.

Anadara trapezia

It may be useful to refer, briefly, to the distribution, *by man,* of *Anadara trapezia* shells in other than their original habitats. *Anadara trapezia* deposits appear to be of fairly recent origin and associated with the lower shorelines and raised beaches.

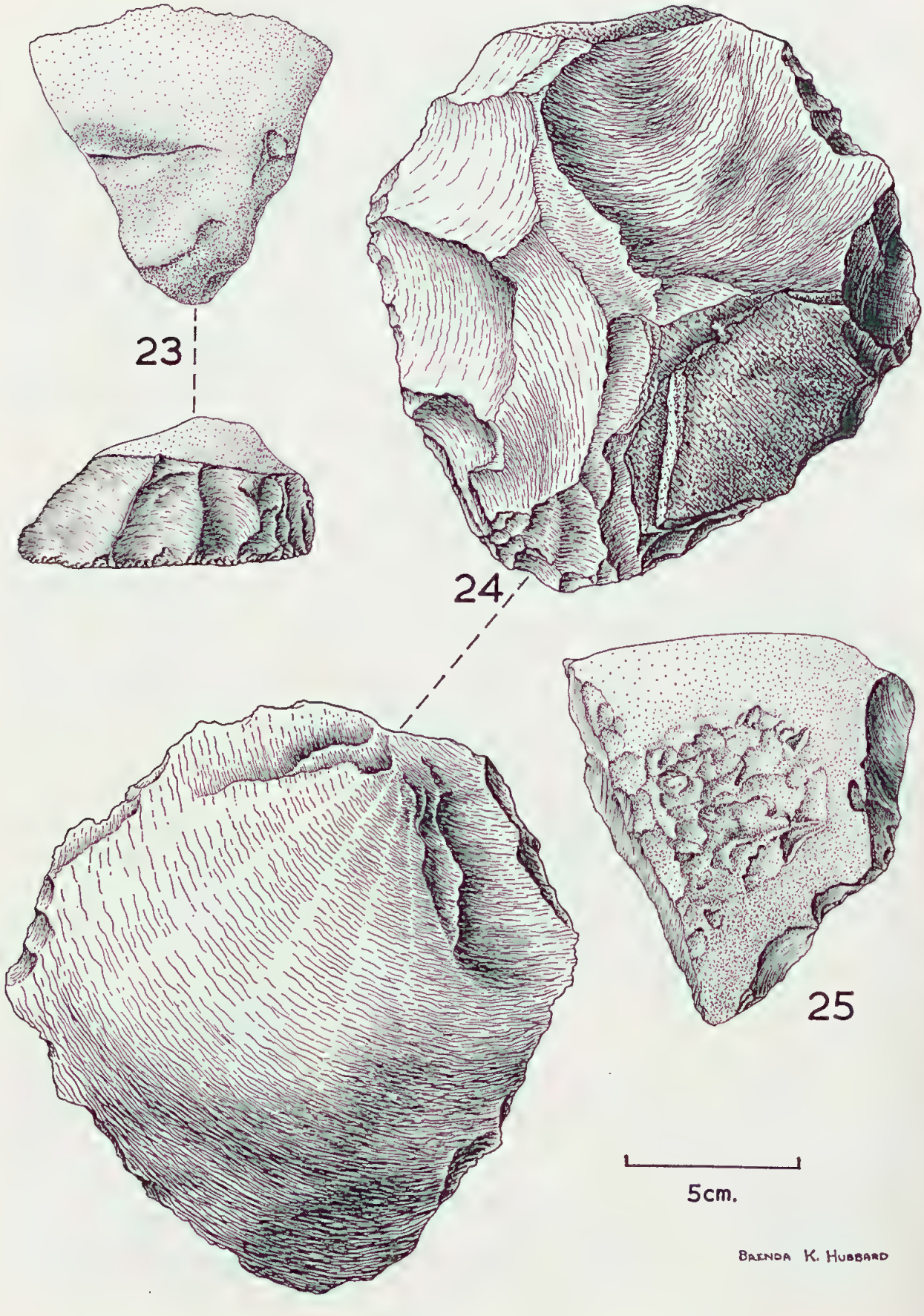
The discovery of some of these shells in the Melton railway yard, at 376 feet above sea level, however, induced the writer to examine the lower, that is the earliest used ballast along the line which made it evident that this was the source from which they were derived.

A detailed and invaluable communication from the South Australian Railways, to whom the writer is deeply indebted, indicated that this material was won from railway ballast pits near Port Wakefield as early as 1868 and used along many miles of track. This ballast is now being covered with crushed quartzite from the Adelaide Hills. Port Wakefield and the old ballast pits are about 18 feet above low water Spring Tides.

CONCLUSION

It was thought preferable in preparing this paper, to confine it, mainly, to a few specific sites, the implements from which, after classification, have proved to possess much in common.

The Hallett Cove site, owing to its size and wealth of material, has been of invaluable assistance but even there the story is no more than partly told. Nevertheless, it seems fairly safe to assume that some of the implements collected were shaped by the first arrivals who made this spot their home.



FIGS. 23-25.

At present, however, it is impossible to indicate which of the implements, found upon the site, belong to this early period and those related to later periods of occupation.

It is apparent that the extent of our knowledge of the individual sections of the successive material cultures, employed by our Australian native people, is relatively small in the establishment of concrete, unassailable evidence, with the exception of those used, during and a little before, historical times.

All the tangible proof of important material cultures, derived from wood, bark, skin, strings, feathers and other perishable substances vanished long ago.

The absence of the written word is another serious limitation, irrespective of whether one excludes or includes their pictorial rock carvings and rock paintings. The meaning and significance of many of these—more especially the carvings—are not perfectly understood; this presents an additional problem.

We are fortunate in the survival, nevertheless, of their almost indestructible stone material cultures, in the form of a profusion of implements of many kinds, together with their work-shops, quarries, and picturesque rock carvings.

These, with the addition of a few relics, composed mainly of shell and bone, provide a vital and unbreakable link with our stone age communities.

Further work in this and other aspects of Anthropology and Archaeology, relating to the native people of Australia, continues to offer interesting and instructive fields of research.

DESCRIPTION OF FIGURED SPECIMENS

All implements have been manufactured from blocks (cores) unless otherwise stated.

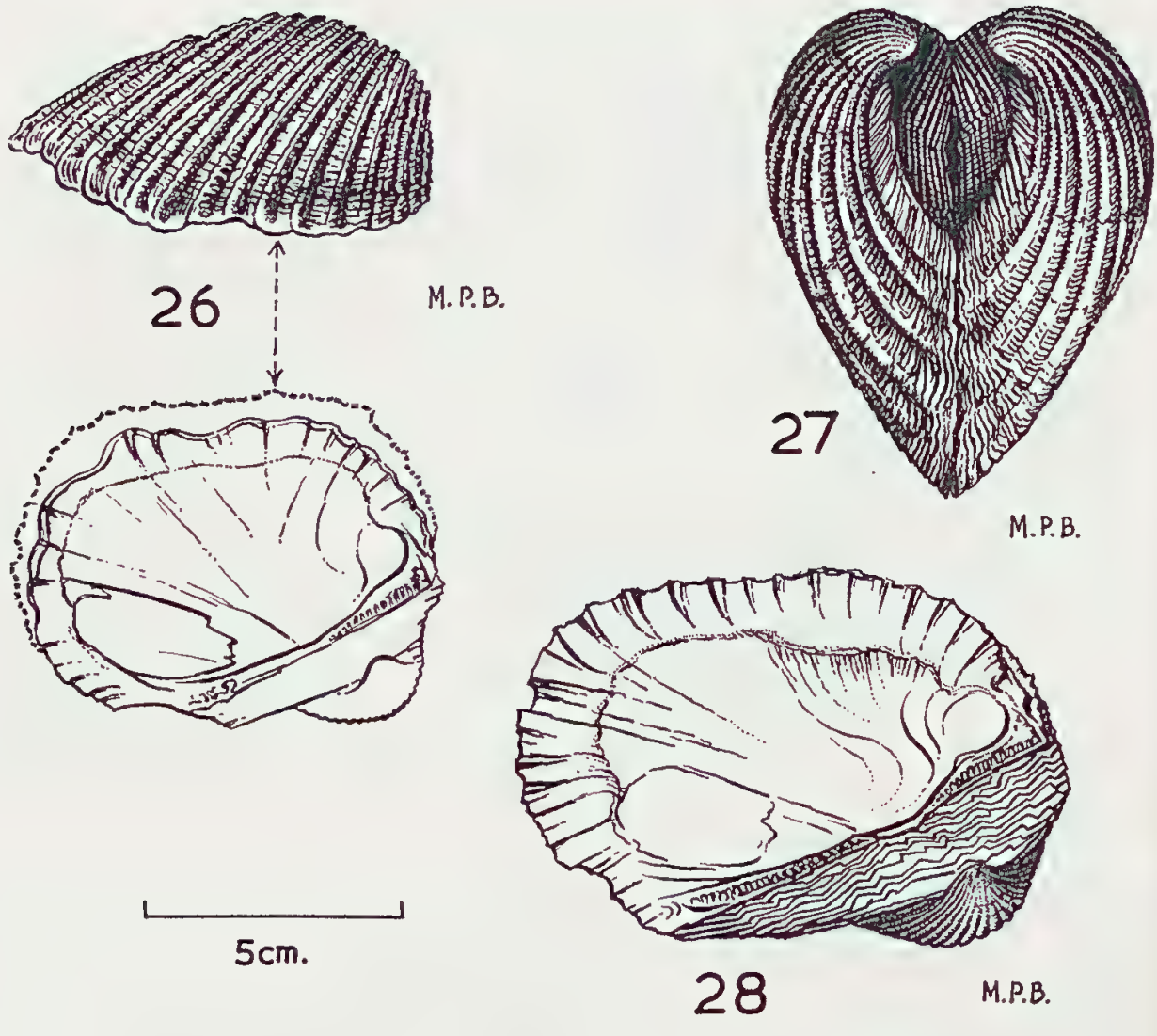
Fig. 1. An unusually large implement with a simple, straight working edge. Pittings on the nether side denote casual use as an anvil or blows caused by a hammer-stone. Weight 12 lb. 1oz. Hallett Cove.

Figs. 2 and 3. Large implements of simple design. Weights 8 lb. 8oz. and 7 lb. 8oz. respectively. Fig. 3 is approximately 1¼ inches in thickness. Both Hallett Cove.

Fig. 4. Secondary stepped trimming confined to a comparatively small "nosed" portion of the circumference of the base which is markedly keeled. Exhibits careful primary flaking overall. Weight 5 lb. 10oz. Hallett Cove.

Fig. 5. A good example of well-executed secondary trimming (stepped) which extends around the whole of the circumference of the base. The existence of this fine specimen was disclosed accidentally, when dismantling a large heap of rocks, collected on the site to facilitate cultivation. Weight 4 lb. 13oz. Hallett Cove.

Fig. 6. An implement with skilful secondary trimming around the whole of its base which is flat and symmetrically oval (6 inches x 4 inches). The side not shown is practically similar to that figured. Weight 5 lb. From a headland overlooking the shore of Lake Bumbunga.



FIGS. 26-30.

Fig. 7. Made from a water-worn, almost discoidal pebble. The margin of its base, which is 4 inches in diameter and slightly rounded, has been neatly trimmed with the exception of a small portion which had been retained as the under side of a striking platform, the top of which is shown at the rear of the drawing. Weight 4 lb. 1oz. From a level paddock, marginal to Beautiful Valley Creek, Wilmington.

Fig. 8. A typical example of many Hallett Cove implements which originated in blocks of stone, non-descript in shape. They appear to indicate that any stone could be used which would provide a simple, single trimmed working edge, whether it be straight, curved or irregular, provided the size and shape of the rock were suitable for successful employment. This specimen, similarly to so many others, possesses pit marks, denoting a casual secondary use as a hammer-stone. Hallett Cove.

Fig. 9. Another massive, irregular block but with its basal circumference secondarily trimmed. It resembles, very closely, many others of similar form collected at Hallett Cove and Melrose. From a level field adjoining the foot of South Hummocks.

Fig. 10. Made from an angular water-worn stone with fine-grained texture which tends to explain its superior secondary flaking. It possesses two distinct trimmed working areas (*a*) one reduced by use and re-trimming which has resulted in an "overhang" and (*b*) another to replace it showing less wear. This was achieved by merely turning the implement over, sideways, and applying the necessary trimming. Melrose.

Fig. 11. Generally irregular in shape but with tolerably good secondary trimming which extends around three-quarters of the basal margin. This working edge has been subject to considerable wear which has caused the development of "overhang" as in the case of Fig. 10. Diameter of base 3 inches. A little below the foot of South Hummocks.

Fig. 12. Somewhat similar to Fig. 11 except that the "overhang" in this case has developed above the whole working edge; good secondary trimming, probably due to the superiority of the type of rock employed and not necessarily to the skill possessed by the operator. This aspect is referred to later in more detail. The excessive wear upon this implement suggests that it was highly prized. Melrose.

Fig. 13. An implement provided with an exceedingly simple straight but efficient working edge. It is characteristic of many similar examples, which occur upon camp-sites referred to in this paper. Wepowie Creek, Orroroo.

Fig. 14. An implement which closely resembles Fig. 13. Hallett Cove.

Fig. 15. A small implement composed of an indifferent coarse gritty quartzite with a hard horizontal vein of milky quartz which has been skilfully utilized to provide it with an efficient trimmed working edge. Melrose.

Fig. 16. Symmetrical in shape (rectangular), flat on both faces and 4 inches in thickness. It has one straight trimmed working edge. Both sides exhibit pitting due to occasional use as a hammer-stone. Melrose.

Fig. 17. Chisel-shaped, with a roughly trimmed working end. Considerably weathered. Prominent pit marks upon both faces. A similar type of implement was found at Hallett Cove. Muston, Kangaroo Island.

Fig. 18. The trimming technique employed in producing this implement, as will be seen, is rough and primitive but it is representative of many others, generally of non-descript shapes found upon this camp-site. It may be a flake implement. Melrose.

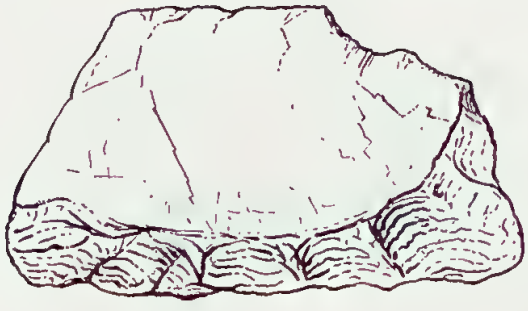
Fig. 19. An implement of unusual shape with regular primary trimming on both faces and also prominent traces of pitting. Its use would be difficult to determine. Thickness 1 inch. Shape and design could suggest that at some time it may have been mounted. Hallett Cove.

Fig. 20. A triangular shaped core implement with well balanced trimming. Sufficient examples of this shape have been found to recognize it as a definite form of implement. Hallett Cove.

Fig. 21. Semi-biface. Constructed from a water-worn pebble 1½ inches in thickness. Has indifferent flaking on both extremities but on alternate sides. Melrose.

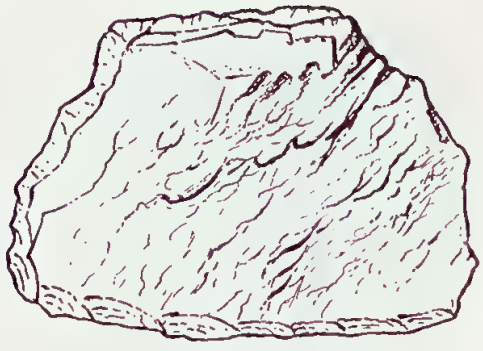
Fig. 22. A small implement. Simple straight-edged trimming has been applied to both ends of one side only. Pit marks. Weight 1 lb. Melrose.

Fig. 23. Angular and retains its natural shape with the exception of the small trimmed portion the form of which is extremely simple. Melrose.

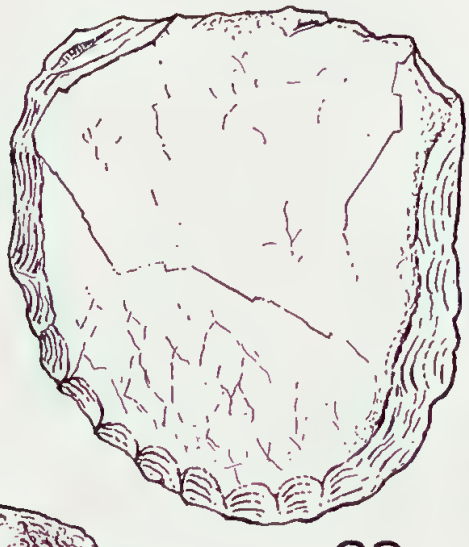


M.P.B.

31

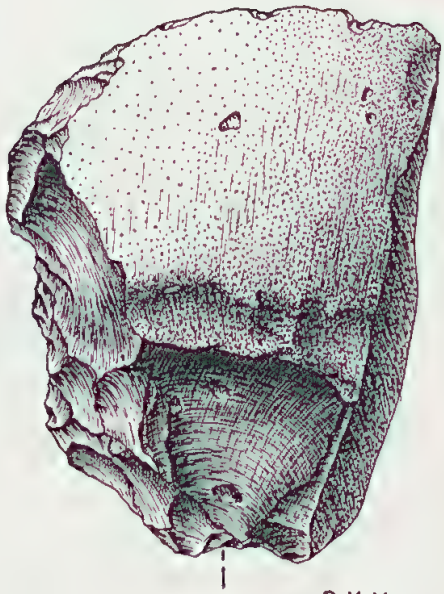


32 M.P.B.



M.P.B.

33



35 B.K.H.

5cm.

M.P.B. 34

FIGS. 31-35.

Fig. 24. A large flake implement. Maximum thickness 1¼ inches. The striking platform or the remaining portion of it, after possible trimming, is ¾ inch in thickness. The working edge seems originally to have extended around the whole of its marginal edge with the exception of a little, each side of the striking platform. This implement appears to have been subjected to considerable wear and tear. It is composed of tough, fine-grained quartzite and considerable skill must have been exercised in effecting the removal of such a massive flake from a refractory type of rock. Hallett Cove.

Fig. 25. Portion of a water-worn flat pebble used extensively as a hammer-stone and also, possibly, as a small anvil. Conventional worn hammer-stones (mostly round and oval-shaped water-worn pebbles) found on most camping spots are extremely rare upon this site which extends along both sides of the Willochra Creek at Melrose. This locality is thickly strewn with thousands of water-worn angular blocks and pebbles, an occasional one of which bears unmistakable pitmarks resulting from its casual utilization as a hammer-stone. This usage, in addition to the existence of similar pitting on the implements themselves (described in this paper) may have some bearing upon the scarcity of clearly defined hammer-stones which are a feature of most native camp-sites. The writer has observed identical conditions where similarly water-worn stones of suitable size and material litter the ground. Also see Cooper (1961).

Fig. 26. Single valve of the sea shell *Anadara trapezia,* showing wear due to use as a scraper, the dotted line indicating its former (and natural) shape. Found upon a narrow but fairly extensive camp-site in low whitish sand dunes a little above high water spring tides, near head of Gulf St. Vincent, where Captain Matthew Flinders R.N., H.M.S. *Investigator,* landed on March 30, 1802, when exploring the coast line and wrote upon his chart at this spot "Signs of Natives". It may be identical with the camping ground where the *Anadara* shell scraper was found.

Fig. 27. Typical but large example of paired *Anadara trapezia* valves discovered intact upon the bed of a salt lagoon in the vicinity of Port Wakefield.

Fig. 28. A single valve of exceptional size weighing 6oz. The above average size of these cockles at the head of Gulf St. Vincent may be due to ideal living conditions in that area. From a salt lagoon in the vicinity of Port Wakefield.

Anadara trapezia, which appears to be a fossil form in South Australia, is still a living species in certain other parts of Southern Australia, especially along coastal districts in New South Wales, where it is known as the Mud or Blood Cockle. Large kitchen middens in those areas indicate its popularity as a favourite food of the natives.

Extensive search at the head of the Gulf, over a considerable period of time, failed to locate similar deposits even on or near camp-sites, including eroded areas. It could be possible, however, that *Anadara* kitchen middens did formerly exist there but have been dispersed since or overlain by other deposits. On the other hand they may have already become a fossil form in the Gulf area before the arrival there of primitive man.

It is true that an occasional shell or two may be found upon camp-sites in the vicinity of Port Wakefield and Port Augusta but this could be due to their use for domestic purposes relating to food or water, their robust construction making them eminently suitable. One example, possibly from the head of Spencer Gulf, where they are plentiful, has been found upon a camp-site in the vicinity of Lake Torrens, having arrived there, apparently, *via* one of the natives' traditional trade routes.

Please see Generalized Discussion for additional notes on this subject.

Figs. 29-34. It seems hardly likely that the conventional well designed slate scrapers, Edwards (1963), used by natives during the historical (European) period, which are all approximately similar in design and shape represent, also, the form or forms of earlier scrapers used by primitive man. They could have been crude and heterogeneous in type and shape from which the recent improved designs were gradually evolved, in much the same way as his stone and other implements.

Skin cloaks were an important part of the needs of the Aborigines in South Australia for protection from the weather during early historical times and if the antiquity of man in Australia extends far enough back from the present to earlier periods, climatic conditions could have been more rigorous during certain phases and the use of protective cloaks may have been more necessary and, perhaps, spread over wider areas. Please see Cooper (1959) for earlier comments.

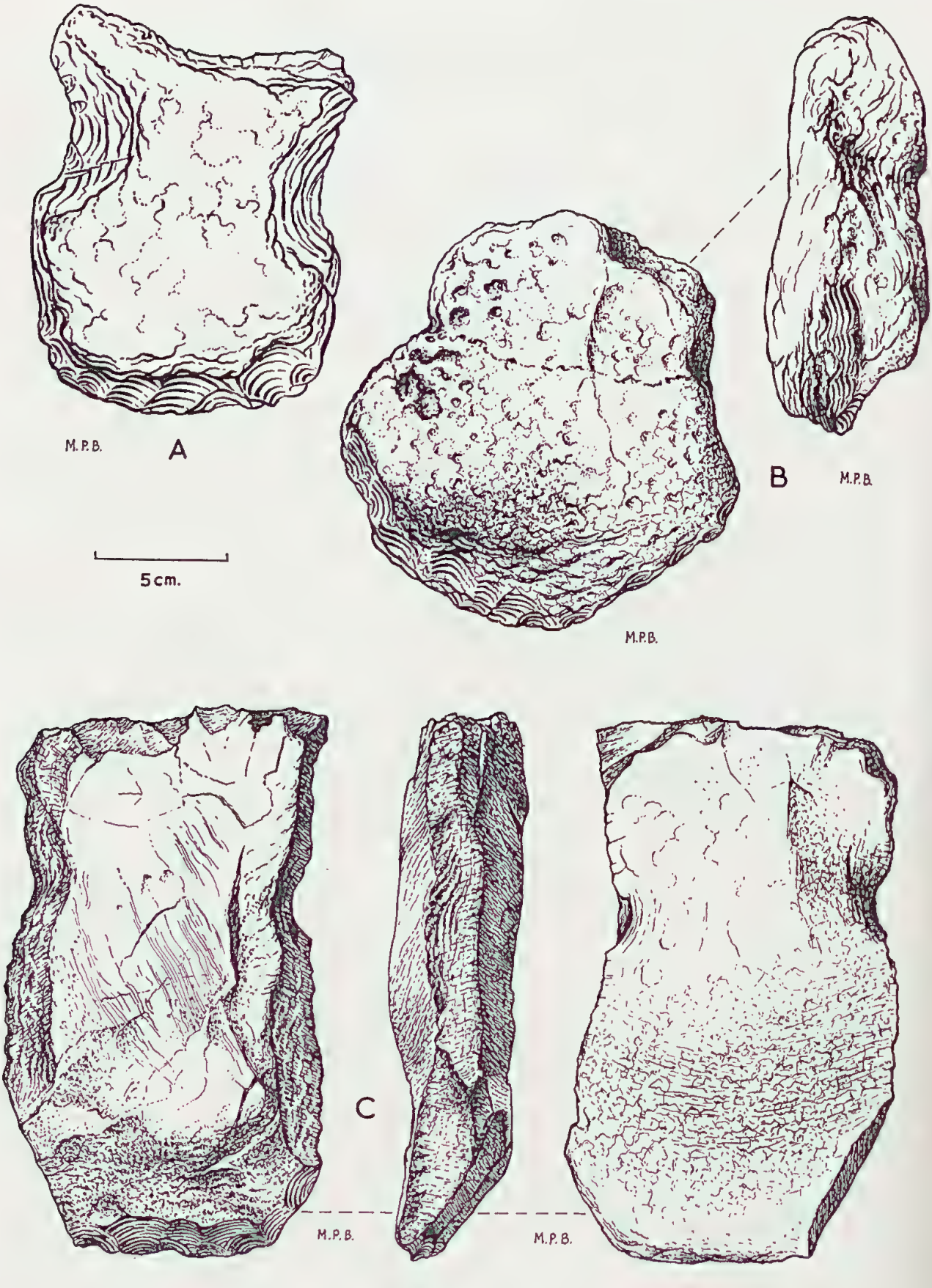


FIG. 36.

Figs. 29 to 34 represent specimens of many forms found upon well established camp-sites to which the material appears to have been transported from elsewhere. They are offered as early forms of potential skin scrapers.

Fig. 29. A scraper possessing the conventional shape including concavity but irregular in form. Three miles north of Ardrossan.

Fig. 30. Has a thin and well defined scraping edge. Port Arthur.

Figs. 31 and 32. Implements with prepared straight edges. Hallett Cove.

Fig. 33. Almost discoidal. Both sides were provided, similarly, with neatly prepared smooth edges. Hallett Cove.

Fig. 34. Trimmed symmetrically to an oval shape. The edges on both sides have been neatly and lightly trimmed. Robertstown District (north of Eudunda).

The implements represented by Figs. 29-34 are made from fragile slaty shales and mudstones. They would prove of little use in resisting breakage if employed in work requiring pressure.

Fig. 35. Made from a water-worn pebble of tillite. The trimmed working edge, considering the intractable, uneven and variable texture of the material used, is remarkably good. One or two other implements made of tillite but with inferior finish, were found. A few blocks of the same material, some showing attempts at flaking, and others merely split open were found, and then apparently discarded because of obvious irregularities in their interior composition. The only favourable aspect in the use of this material appears to be its extreme hardness and, in consequence, resistance to wear.

It may be of interest to add that a small glacial erratic of Porphyry, with tolerably good flaking qualities and found at Hallett Cove, had been shaped to form a trimmed core implement.

Large block implements (not figured).

(*a*) Melrose. 5 lb. 6oz.
(*b*) South Hummocks. 10 lb.
Both possess stepped trimming.

Some Stone Implements, Possibly Mounted

It is probable that the reader's first impression after examining Figs. 36 A-C and 37 D-H, which represent types widely divergent in shape, size, design and technique, will be one of uncertainty regarding their use as hafted implements.

It can be seen, however, from an examination of the figured specimens already described, many of which belong to periods remote from the present, that wide diversifications in shape, size, design and technique also appear amongst them. The employment of A to H as mounted implements, irrespective of their possible uses may be strengthened by the absence of any widely distributed conventional type with which they could be associated, such as that apparent in the comparatively recent polished stone axe-head group of the South-East of South Australia and elsewhere.

Fig. 36, A. An implement with a deep groove for hafting chipped out of both edges. A trimmed working edge has been applied to the base on both sides. There are indications of considerable wear. The natural surface of the rock is intact elsewhere. Maximum thickness is 1⅛ inches. Both sides of the implement are similar. Near Birchmore Lagoon, Kangaroo Island.

Fig. 36, B. A massive implement with grooving on both edges. The worn base suggests wear due to pounding blows. Weight 2¾ lb. Wepowie Creek, Orroroo.

Fig. 36, C. Roughly rectangular in shape with prepared side grooving. The head of the implement has rough primary flaking and the straight working edge is trimmed upon one side only. This implement appears to have been made from a massive flake. Weight 3 lb. Wepowie Creek, Orroroo.

Fig. 37, D. Made from a tough quartzite water-worn pebble and has well defined edge-flaked hafting grooves. The natural surface of one side is intact. The lower portion of the other side has been primarily flaked with a clearly defined but somewhat worn secondarily trimmed working edge. Near Cape Hart, Kangaroo Island.

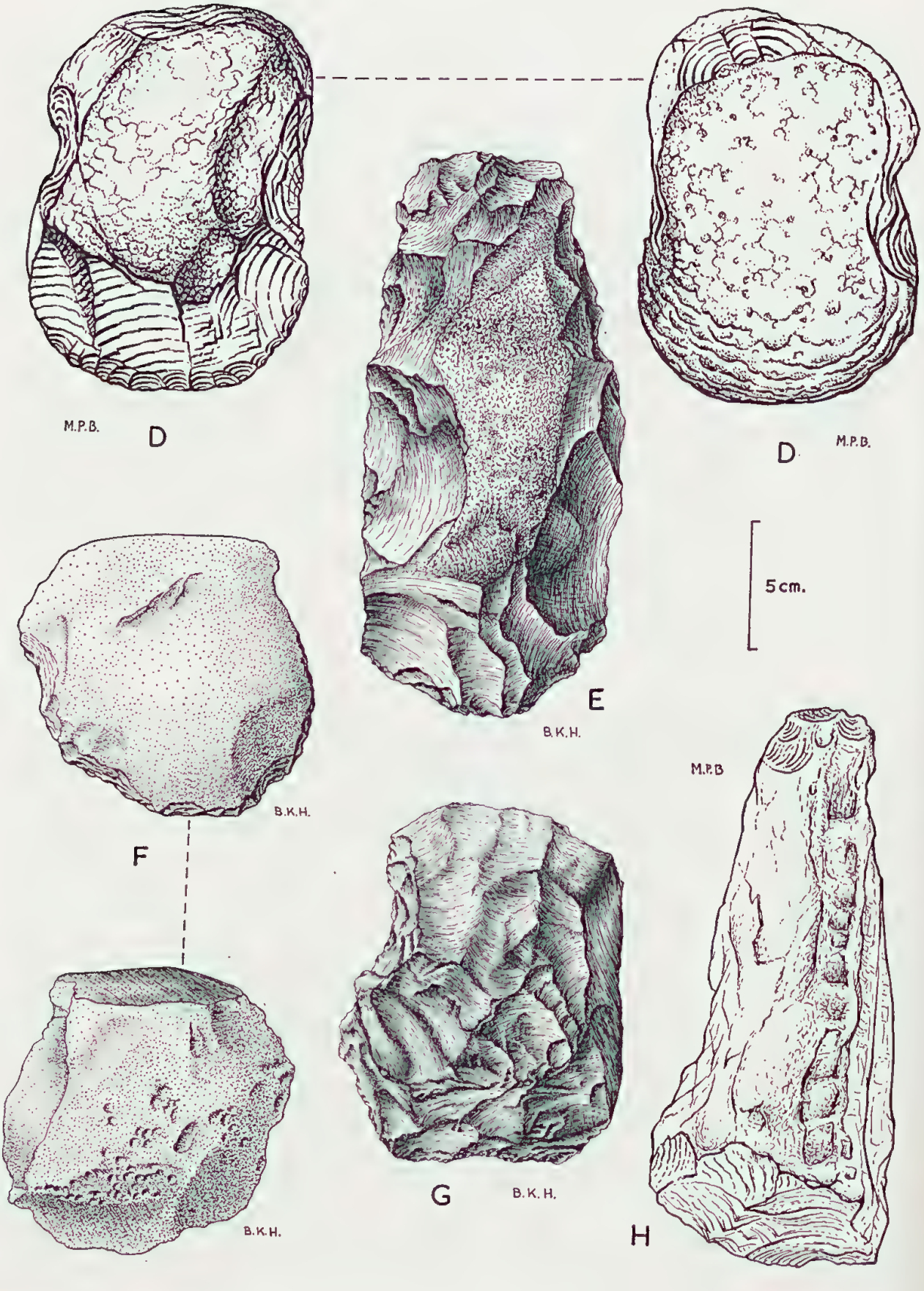


FIG. 37.

Fig. 37, E. Has primary and secondary trimming on the side shown; the reverse almost similar. This implement, with semi-biface primary trimming, has the appearance of possessing an ill-defined hafting groove. E and H may be of interest because they appear to resemble others discovered in England, figured in Evans (1872). Maximum thickness 2 inches. It is highly improbable that the similarities are more than accidental. Hackham.

Fig. 37, F. Rounded trimming along basal working edge on one side only. Flaked concavities on both side edges, perhaps for hafting. Reverse side bears deep pit markings. Well defined primary flaking to shape working platform at head of implement. Hallett Cove.

Fig. 37, G. Both sides of this implement have been completely shaped by careful primary flaking. The base has a well defined trimmed edge. A deep, carefully worked notch will be noticed on the left hand edge. If this were a hafted implement the notch may indicate that such a feature could be sufficient to ensure the security of a hafting. Five implements of the same size, with somewhat similar notching on one edge only, have been found at Hallett Cove and another at Wepowie Creek, Orroroo. Thickness 2 inches. The striking platform (at apex) has been reduced in thickness by judicious trimming. Hallett Cove.

Fig. 37, H. A semi-biface implement. Roughly trimmed on both sides by the removal of primary flakes, some of large size, although the natural surface remains in places. Striking platform at apex is small due to the removal of material by flaking. Secondary trimming is confined to the working edge upon one side only. Maximum thickness 1¾ inches. For comparison with English types please see Fig. 37 E and also Generalized Discussion. Hackham.

NOTE. It was found impossible to provide two or more views of some of the figured specimens but descriptions of them were made as detailed as possible to assist the reader.

For further examples of implements, possibly mounted, please see Cooper (1959 and 1960).

ACKNOWLEDGMENTS

It is desired to acknowledge, with many thanks, the assistance afforded by the following:—Mrs. A. E. Stone and Mr. K. Stone, Hallett Cove, for permission, readily given at all times, to examine over a period of many years an old native camping ground of considerable scientific importance existing upon the property; Mr. K. McCallum, Mrs. L. Arthur and Mr. and Mrs. M. Blinman and Sons, all of Melrose; Mr. and Mrs. R. R. Underwood of Port Wakefield; Mr. T. Clark, Pekina; Mr. V. P. Daly, Wilmington and many other land owners who generously made access to their properties possible; Dr. D. W. P. Corbett, Curator of Fossils and Minerals, South Australian Museum, for assistance in identifying many rock types; the South Australian Railways Commissioner for invaluable information relating to the use of fossiliferous material as railway ballast and Miss M. P. Boyce, Miss B. Hubbard, South Australian Museum, and Mrs. V. Haley, formerly of the same institution, for the excellent drawings.

REFERENCES

Cooper, H. M., 1943: Large Stone Implements from South Australia. *Rec. S.A. Museum,* Adelaide, 7, pp. 343-369.

———— 1948: A "Nosed" Scraper. *The South Australian Naturalist,* 25 (1), pp. 5-6.

———— 1959: Large Archaeological Stone Implements from Hallett Cove, South Australia. *Trans Roy. Soc. of S. Aust.,* Adelaide, 82, pp. 55-60 and plates 1-4.

———— 1960: The Archaeology of Kangaroo Island, South Australia. *Rec. S.A. Museum,* Adelaide, 13 (4), pp. 481-503.

———— 1961: Archaeological Stone Implements along the Lower River Wakefield, South Australia. *Trans. Roy. Soc. of S. Aust.,* Adelaide, 84, pp. 105-115.

Edwards, R., 1963: Preliminary Survey of the Aboriginal Reniform Slate Scrapers of South Australia. *Rec. S.A. Museum,* Adelaide, 14 (3), pp. 515-524.

Evans, J., 1872: *The Ancient Stone Implements, Weapons and Ornaments of Great Britain.* London.

Gillespie, Dr., 1877: On Flint Cores as Implements. *Roy. Anthropological Inst.,* London, pp. 260-263.

Holmes, W. H., 1895: Archaeological Studies among the Ancient Cities of Mexico. *Field Columbian Museum,* Chicago, pp. 285-288 and plate.

AN ARCHAEOLOGICAL CAMP-SITE IN THE VICINITY OF HALLETT COVE, SOUTH AUSTRALIA

By H. M. COOPER*

SUMMARY

This paper describes an archaeological camping ground inland from Hallett Cove.

The unusual type of rock employed in the manufacture of the large stone implements found upon it is described and a comparison is made with those collected upon other sites in the vicinity.

The difficulties confronting any accurate assessment relating to the age and correct cultural succession of the large stone implements of Australia, owing to the present lack of reliable evidence, is discussed in detail.

THE CAMP-SITE AND ITS STONE IMPLEMENTS

The land where the camping ground was found, and in its vicinity, is generally undulating in character and intersected by a few gullies, some steep, together with their small associated watercourses which trend westwards towards the sea. All are dry throughout the year with the exception of brief periods after heavy rains.

No vestige of the original native flora remains, with the exception here and there, of a few specimens of *Casuarina stricta* (Sheoak), *Melaleuca pubescens* (Tea-tree), *Eucalyptus* (Mallee sp.) and *Pittosporum phillyreoides* (Native Apricot).

The land, mostly agricultural, is littered in many of its fields with a mantle of small and large blocks of Travertine Limestone most of which appear to have been dislodged and brought to the surface during cultivation.

An extensive outcrop of Pliocene Sandstone, highly fossiliferous in places and about half a mile in length, is exposed a little below the crest of a ridge which trends, approximately, in the general direction of N.N.E. and S.S.W. It was from this material that the aboriginal stone implements described in this paper, were made.

The ridge being officially unnamed, has been designated, for the purpose of this paper, Sheidow Ridge, in deep appreciation of the owner's courtesy in readily granting access to his property over a considerable period of years. Its average height above sea level is approximately 320 feet and its distance inland from Gulf St. Vincent about three-quarters of a mile.

* Honorary Associate in Anthropology, South Australian Museum

There occur, upon the gently sloping surface of the field immediately below the outcrop, many smooth, angular and heavily weathered blocks of Pliocene Sandstone, derived apparently from the outcrop itself which, after examination, failed to disclose little if any evidence that it was the direct source from which the implements were made.

The weathered out blocks upon the ground just below it, however, included a large number of various shapes and sizes suitable for trimming into the several forms of large stone implements which were found lying amongst them. It would appear beyond doubt, therefore, that here was the source from which the natives drew their rock material.

The locality of the camp-site as indicated by the presence of the stone implements strewn upon its surface, is situated towards the S.S.W. extreme of the outcrop and appeared to cover a comparatively small area. It is bisected by a small but fairly steep gully down the centre of which runs a dry watercourse with definite evidence, in the form of scour, of water flow after rains. It is possible that at a remote period it may have been more or less permanent. There is a commanding view of the surrounding country-side in many directions from this spot.

The presence upon the site of a large number of Travertine Limestone blocks, already referred to, made collecting a very slow and tedious operation.

The examination and subsequent confirmation of possible secondary and even primary, deliberate flaking upon some of the material needed, during its early stages, great care owing to the unusual type of weathering existing upon the surface of the Pliocene Sandstone blocks, a rock type seldom, if ever, employed consistently in South Australia for this purpose.

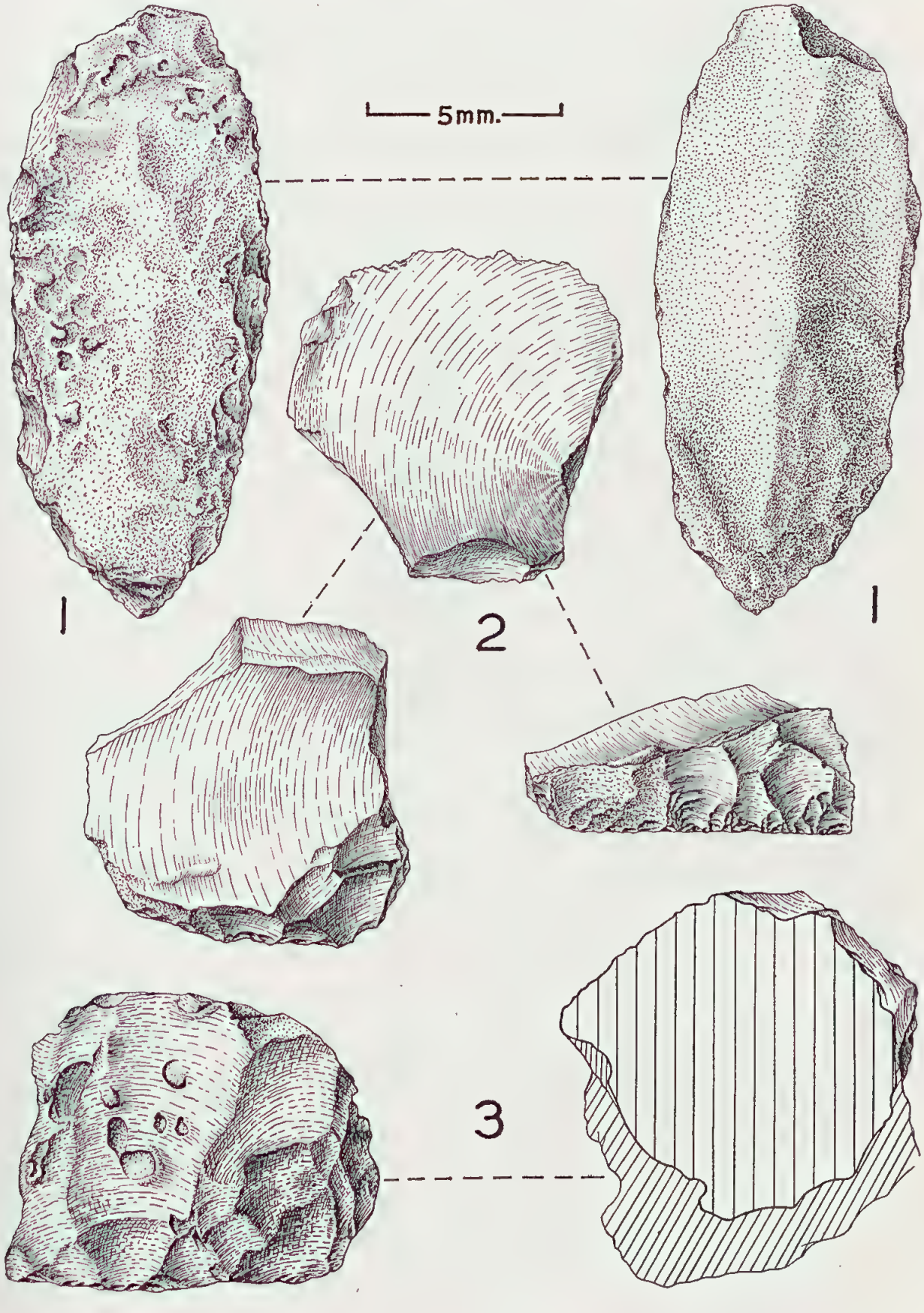
Invaluable aid, however, in finally determining that these specimens were trimmed implements, was forthcoming after comparing them, very carefully, with well established types from the large camp-site area at Hallett Cove. It then became evident that certain types from both locations were clearly comparable.

DESCRIPTION OF FIGURED SPECIMENS

Fig. 1. A symmetrically-shaped pick-like implement, both edges and pointed base being neatly trimmed. The reverse side, strongly keeled, retains its natural surface. A somewhat similar pointed implement, not yet described, was found near Hackham, 9 miles distant. Maximum thickness 1¾ inches.

Fig. 2. Derived from a massive flake. It possesses clearly defined primary and secondary trimming along portion of its curved basal circumference and a well-defined striking platform. Maximum thickness 1¼ inches.

Fig. 3. "Horsehoof" type implement made from a highly fossiliferous block. It is trimmed around most of its base, similarly to the procedure generally adopted in designing this type of tool. Heavy use is indicated by the battered state of the working edge where wear in places has resulted in an "overhang". The base, considering the fossiliferous nature of the rock, is comparatively flat. Weight 1½ lb.


5mm.
1
2
1
3

The existence, however, of primary and secondary trimming upon many of these implements from Sheidow Ridge, including those figured in this paper, is self-evident and did not need any lengthy scrutiny.

No evidence was found of the existence of any of the conventional well-worn hammerstones, so often associated with most camping grounds. This seems to indicate that the natives were content to pick up and employ any casual block of convenient shape and size, amongst the hundreds available, for trimming and flaking purposes, after which it was discarded. A similar absence of conventional hammerstones was noticed at certain other sites, including Melrose where quantities of weathered out blocks of quartzite and other suitable rock material litter the surfaces of the camping grounds and their immediate vicinities. These were utilized for temporary use in a similar manner.

Many large implements found upon Kangaroo Island, the network of sites at Hallett Cove and elsewhere, carry pit marks, the result of their casual use as hammers. Some of the specimens from Sheidow Ridge bear similar scar marks, although a little difficult to detect owing to the characteristic weathering of the type of rock employed there.

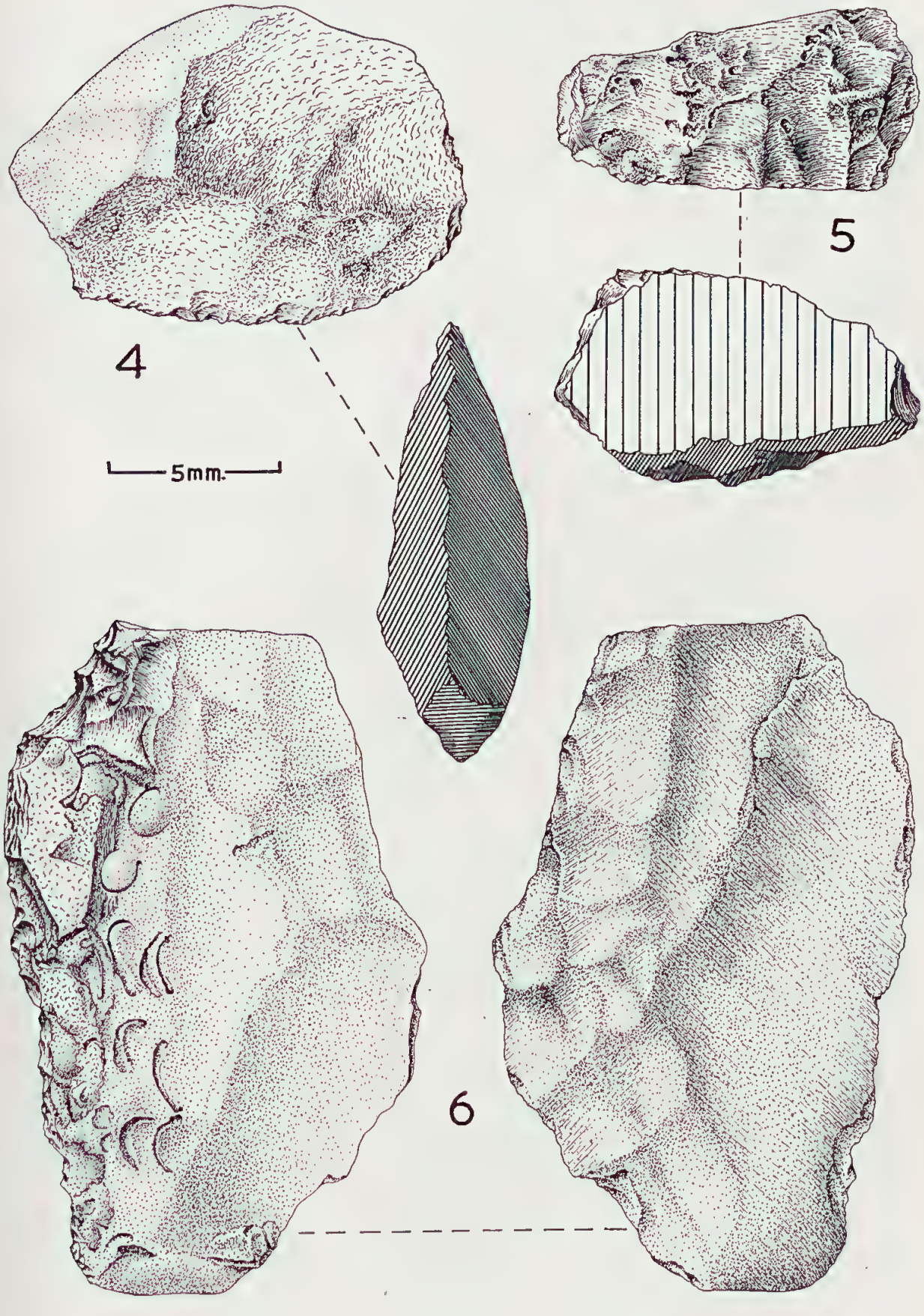
The camping ground, if one may be guided by the area upon which the implements were found, appears to have been comparatively small and confined, almost exclusively, to a fairly narrow strip just below the outcrop. It is bisected, as already remarked, by a small gully running east and west.

The implements discovered, with the exception of Fig. 2, which is a fairly massive flake, have been derived from angular blocks of appropriate size, their natural shape, apparently, being of little, if any, importance, always provided that provision could be made for the addition of a simple, straight or curved working edge, trimmed along a selected natural border of the stone by the removal of primary and secondary flakes—sometimes primary only. A few additional flakes were sometimes struck off, here and there,

Fig. 4. Provision for the application of a secondary trimmed working edge (as figured) was provided by the removal of primary flakes. Portion of the striking platform remains. The natural surface upon the nether side is intact but scattered pit-marks there are evidence of its casual use as a hammerstone.

Fig. 5. A flat-based implement which has been trimmed around the semi-circular part of its circumference. Heavy wear here is indicated by the battered and worn condition of its working edge. The cutting back of the base has caused the face of the implement on this side to become almost vertical. The tool after reaching this condition would have lost most of its usefulness. Many similar worn but interesting large implements may be collected upon sites elsewhere.

Fig. 6. A long massive implement made from a fossiliferous block. Its rough, jagged working edge is due, principally, to the irregular placement of many bivalve casts. Its weight, during use, would have been an advantage. Portion of the striking platform remains. Also see text. 3¼ lb.


4
5
5mm.
6

to remove, apparently, portions of the rock inconveniently situated. Some of the implements possess well defined and, sometimes, massive striking platforms.

The occurrence at Hallett Cove of large quantities of trimmed core implements utilizing this simple shaping and trimming technique, including many worn back by use to a remarkable degree, seems to be proof that they were successful working tools, at least during the period or periods which they represent.

It was thought appropriate to confine the comments expressed in this paper generally to the Hallett Cove area with its extensive network of camping grounds rather than attempt a wider coverage, which explains the many references to that locality.

The subject matter discussed however, could apply equally to many other districts in Australia.

The number of large implements found on the Sheidow Ridge site, during the course of 15 examinations, amounted to 55 approximately.

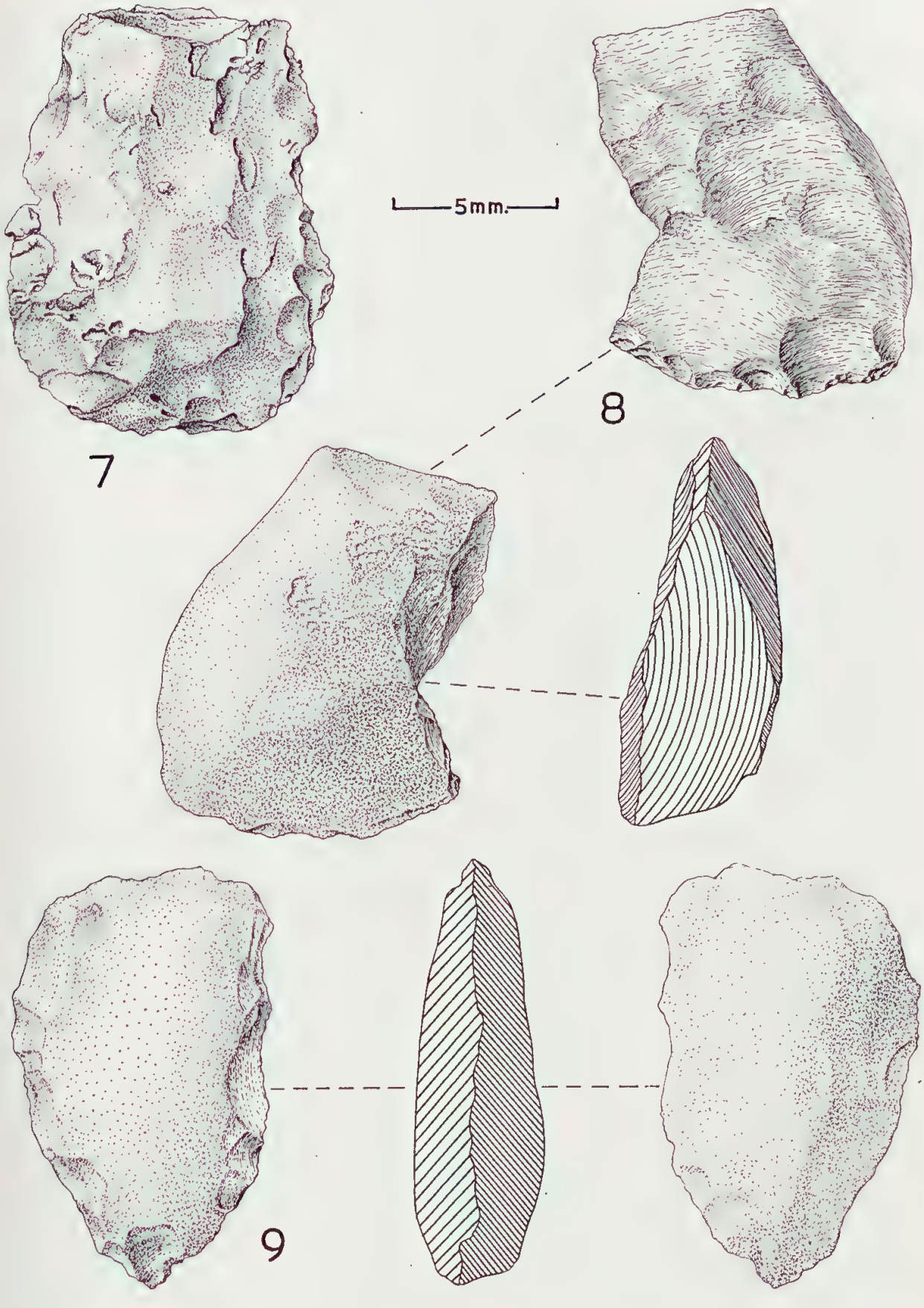
It is difficult to explain the reason which prompted the deliberate and consistent use at Sheidow Ridge of Pliocene Sandstone, an indifferent type of rock, significantly ignored by the natives elsewhere in the Hallett Cove area. It may have been due to its exceptional hardness and consequent resistance to wear but this seems hardly convincing enough in the presence of fine-grained quartzites in the neighbourhood. Its use, alternatively, may have been due to any one of many other causes, possibly a very simple one but which unfortunately, with the passage of time, it is now too late to determine.

Several of the implements were trimmed from highly fossiliferous Pliocene Sandstone blocks including Fig. 6 which is in large part composed of bivalves and casts. This implement at first sight gave the appearance of being indifferently made because the trimming applied to it resulted in a very jagged working edge, made worse by the presence of many irregularly placed shells.

Fig. 7. Made from highly fossiliferous material containing shells, casts and small pieces of miscellaneous rocks. Possesses a pronounced striking platform. The trimming, similarly to Fig. 6 is rough due to its composition. Its design and shape, similar to others at Hallett Cove proper seem to indicate its possible use as some primitive form of chopping axe, either hafted or held in the hand. Both sides of this implement are almost similar. Maximum thickness 2¼ inches.

Fig. 8. An implement of simple design with a well-defined almost straight working edge, secondarily trimmed. It is comparable with many others found at Melrose, Hallett Cove proper and elsewhere. The nether side, with evidence of pitting due to casual hammering, retains its natural surface. Possesses a striking platform.

Fig. 9. An implement of pointed shape with even trimming mostly primary, along both edges. The natural surface of the reverse side remains untouched.


5mm.
7
8
9

Indications after a trial test, however, showed that when this implement was employed for rough scraping, chopping and sawing purposes, it proved to be a most efficient tool. The choice of material used and the consequent rough and jagged working edge, produced in consequence, may have been deliberate. Fig. 7 is a similar comparable example. Others were also found.

The average size of the implements from Sheidow Ridge is a little below that of those, generally, from Hallett Cove proper and the individual types are less. No small implements, including microliths, were found.

A comparison between the chosen locality upon the ridge and those at Hallett Cove is interesting. The usual requirements for a native camp-site were followed, generally, at Hallett Cove proper, that is, an extensive view, proximity to a water supply, gradually rising but well drained soil, sandy or loamy if possible, and devoid of rocks. One disadvantage, but probably a minor one, necessitated the gathering and transportation to the site of suitable implement making material.

At Sheidow Ridge however, a site was chosen which provided upon the spot, *in situ* as it were, all the rock material required. This site possesses at the present time, none of the conventional requirements of a camp-site with the exception of a fairly extensive view in some directions. This unusual choice of site, therefore, may have been deliberate owing to the presence of the rock material upon it.

The implements found upon the Ridge Site appear to possess much in common which seems to indicate that natives of no more than one culture period resided there. Its dating for the present remains indeterminable. The site, upon the other hand, may not have proved attractive to others at a later period.

This apparent sole occupational culture period at Sheidow Ridge is in marked contrast to the extensive network of sites at Hallett Cove where the diversity of implement types indicates their occupation at different periods, probably over a considerable space of time but even here there appear to have been periods when the sites were deserted. This may account for the absence of Pirri and other microliths widely distributed elsewhere.

In the apparent absence of local topography, favouring the existence of rock shelters and other spots suitable for stratification, the importance of surface material in vast quantities such as that collected at Hallett Cove—of various types associated obviously with different culture periods—is invaluable because it includes all the different types of implements, employed by the people residing there, from their remotest occupational period until the last.

This does not assist us unfortunately, in arranging in their correct order, the periods which they represent or their age. Stratified material found in various areas has already proved to be of inestimable value in the direction of assessing their correct sequence and Carbon 14 datings in estimating their respective ages. This has been especially useful in relation to small implements. Stratifications relating to large stone implements, however, have been disappointingly few in number.

Explorations for stratified implements and suitable material for Carbon 14 datings have been and continue to be carried out by dedicated researchers. This work is being recognized, more and more, as an indispensable part of Australian Archaeology.

If the lack of stratified deposits of large early implements, discovered up to the present persists, it may be due to some obscure cause, such as the topographical and climatic features existing during those periods or even, perhaps, to the native population at that time being very small in number and widely scattered.

All the more recent culture periods seem to have witnessed the gradual disappearance of the large and bulky material due to the introduction of various types of medium size including beautifully worked flakes, "Tula" adze scrapers, knives and others. A need would still remain however for employing large tools for some purposes of a heavy nature including chopping down large boughs, cutting out wooden blocks of considerable size and roughly scraping them in the initial stages of the preparation of domestic and other articles.

It would be most interesting to ascertain, therefore, whether any of the earlier well-proven types of large tools persisted into the more recent periods, where the small implements appear to have been dominant, for purposes such as those referred to above. This could be ascertained, in part at least, by the discovery of some substantial stratified large implement deposits with associated Carbon 14 datings. These discoveries furthermore, would enable a beginning to be made in classifying the dominant types, at least, which exist amongst the vast accumulation of large implements awaiting attention.

The widely distributed "Horsehoof" trimmed core type, which exists in many variations of shapes, sizes, simple and more complex trimming technique and skill in workmanship (after taking into consideration the degree of suitability of the rock employed) is a possible example if the existence of this "overlap" proves to be true.

The stone implement culture of the long extinct Kangaroo Islanders, believed to be of considerable age, includes conventional specimens of the "Horsehoof type".

The unfortunate scarcity, up to the present, of stratified large implement types, the consequent lack of knowledge relating to their culture sequence and age dating confront us with a serious problem and if, in addition, one lays aside all assumptions, possibilities, probabilities and hypothetical theories relating to them the amount of unassailable evidence remaining to us is extremely small.

If there is one essential and indispensable requirement it is—the discovery of many more stratified deposits of this material in many and widely separated areas. This would assist, materially, in placing the more plentiful and widely distributed types into their correct succession periods and if correlated Carbon 14 datings are also available the time rate of diffusion and its directional aspects would prove of value and interest. This time dating, however, may be approximate only because the particular deposit being examined would not necessarily be the earliest one for that locality.

Meanwhile the many thousands of large stone implements in a wealth of types, weights, sizes and in varying grades of design and workmanship remain carefully stored in many Australian National Institutions (including a vast number in the South Australian Museum), until such time when much more information is available, which it is hoped may not be far away.

It will then be possible to assign to this invaluable material—some of which must surely represent the earliest stages of the Antiquity of Man in Australia—their correct succession in the material culture periods of our former native peoples.

ACKNOWLEDGMENT

It is desired to acknowledge, with appreciation, the admirable drawings made by Miss Brenda Hubbard, South Australian Museum, for this paper.

REFERENCES

Cooper, H. M., 1943: Large stone implements from South Australia. *Rec. S. Aust. Mus.*, Adelaide, 7, pp. 343-369.

———— 1959: Large archaeological stone implements from Hallett Cove, South Australia. *Trans. R. Soc. S. Aust.*, Adelaide, 82, pp. 55-59.

———— 1960: The archaeology of Kangaroo Island. *Rec. S. Aust. Mus.*, Adelaide, 13, pp. 481-503.

———— 1968: A further description of large stone implements from South Australia. *Rec. S. Aust. Mus.* (in press).

NOMENCLATURE OF ARCHAEOLOGICAL CULTURES AND ASSOCIATED IMPLEMENTS IN AUSTRALIA[1]

By NORMAN B. TINDALE, South Australian Museum

(Submitted October 12, 1965)

Figs. 1-17

SUMMARY

Principles governing a study of Australian archaeological cultures are given with illustrative examples.

The importance of named culture phases: the Tartangan, Pirrian, Mudukian and Murundian found at Tartanga and Devon Downs in 1929 and the earlier Kartan Cultures are reiterated. Some alternative interpretations are reviewed, and new radiocarbon dates are quoted in support of the views expressed. An *elouera* and several geometric microliths from Pirrian and Mudukian levels at Devon Downs and elsewhere are depicted; also two implements from Kangaroo Island are illustrated and discussed because their misinterpretation in later writings has led to erroneous conclusions of far-reaching significance. Geometric microliths from Western Australia, with remains of resin mountings and made from glass, of modern date, and a hafted knife of *pirri* type from Barrow Creek are used to illustrate a statement on the presence of culture gradients in Australia.

There are two appendices, one a brief history of some of the author's archaeological activities since his field work began on Groote Eylandt in 1921, and the other a bibliography.

CONTENTS

	Page
Culture concepts in Australian Archaeology	616
Nomenclature of Cultures and Industries	625
Functions and recording of archaeological implements	628
Illustrations of implements	631
Archaeological collections	631
The archaeological succession in south-eastern Australia	634
Appendix I. Historical notes on some Australian cultures and their marker implements	637
Appendix II. References	639

[1] A draft of this paper was read and circulated at a working conference of the Australian Institute of Aboriginal Studies in April 1963.

CULTURE CONCEPTS IN AUSTRALIAN ARCHAEOLOGY

Several concepts have developed since archaeological studies began in Australia. These may be called—

The Monocultural Concept.
The Culture Succession Concept.
The Multi-cultural Concept.

The Monocultural Concept

Early interpretations of Australian aboriginal culture stressed its seeming unity in area and time. Writers, including the late A. S. Kenyon, gave little heed to an archaeological past and tended to consider everything they found as belonging to an ethnological present.

The latest exponent of this monocultural concept was the late S. Mitchell (1949) who had many years of association with Kenyon. In the introduction to his book he denied the existence of a culture sequence in Australia. To him all known types of aboriginal artefacts represented a continuing single culture. He named many local industries, using present-day tribal names as basis for his nomenclature. He followed a precedent set by Howchin (1934) who described the implements found on the Adelaide plains, without regard to any possible time factor, as all of the Adelaide tribe. Some of the implements collected by Howchin were of Pleistocene date, upwards of 10,000 years old, whereas the *pirri* implements were Mid-Recent in southern Australia, and his stone axes were of even more modern date.

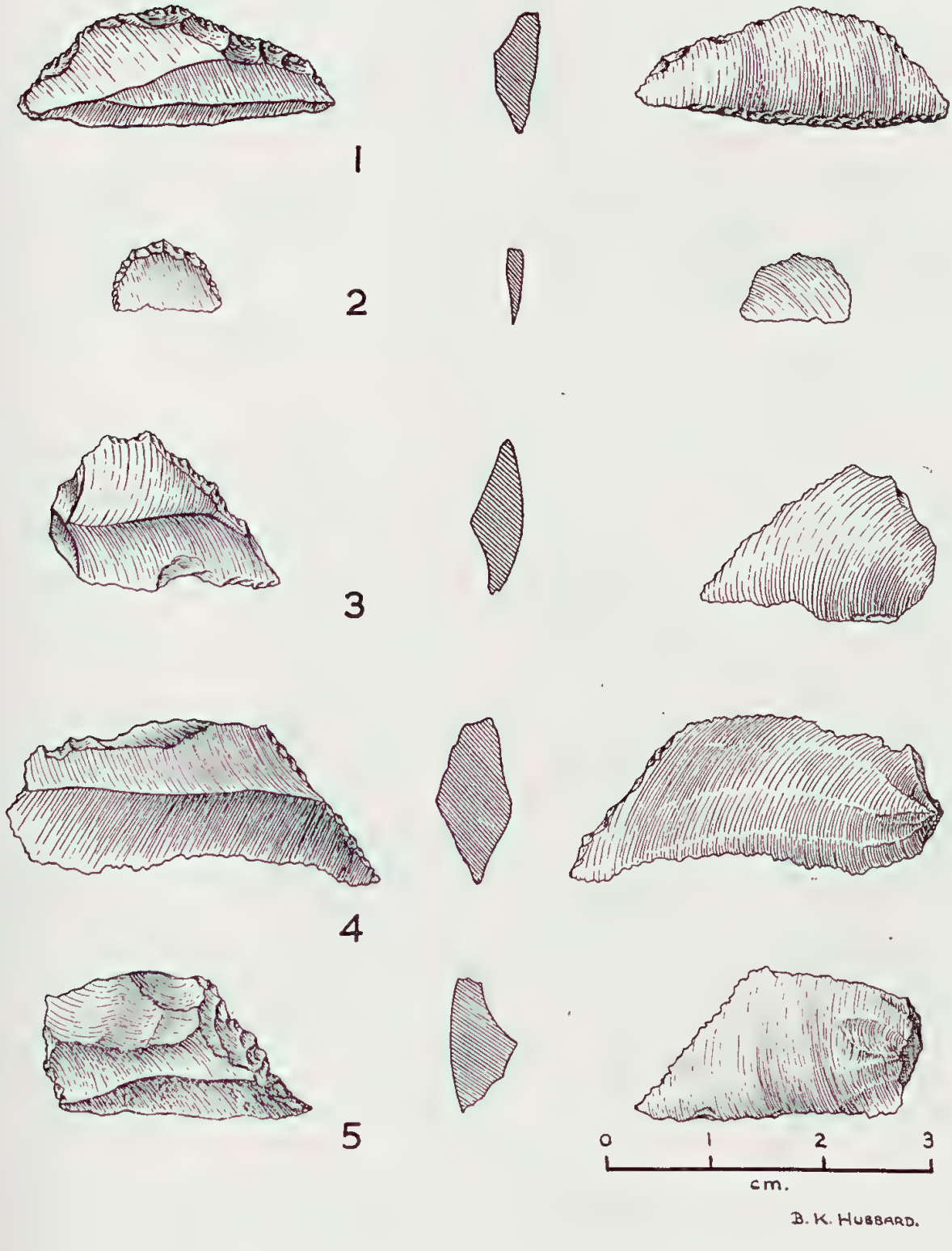
The Culture Succession Concept

Excavations at Tartanga Island and at Devon Downs (Hale and Tindale 1930) revealed evidence for cultural shifts in the remains of human occupation, accompanied by indications of physiographic changes in the Lower Murray Valley.

A succession of cultural phases Tartangan, Pirrian, Mudukian and Murundian were named.

FIGS. 1-5. MUDUKIAN TYPE MICROLITHS FROM SEVERAL LOCALITIES

Fig. 1. Crescent microlith with reverse retouch. Policeman Point, Coorong, South Australia, in red earthy layer of exclusively Mudukian site (A.48267 in S.A. Museum), collected by N. B. Tindale. *Fig. 2.* Crescent microlith, small example from eroded surface, Policeman Point (A.48275), Mudukian Culture. *Fig. 3.* Woakwine Point in red earthy layer, Policeman Point (A.48270), Mudukian Culture. *Fig. 4.* Woakwine Point, Site 7, South-East of South Australia, T. D. Campbell (A.48810). *Fig. 5.* Woakwine Point, Blundell Valley, west of Canberra, A.C.T., collected by N. B. Tindale (A.54331).


1
2
3
4
5
0 1 2 3
cm.
B. K. Hubbard.

A year later evidence on Kangaroo Island (Tindale and Maegraith, 1931) suggested a still earlier culture phase, afterwards recognized as principally of Pleistocene age. This was named the Kartan Culture (Tindale 1941: 145).

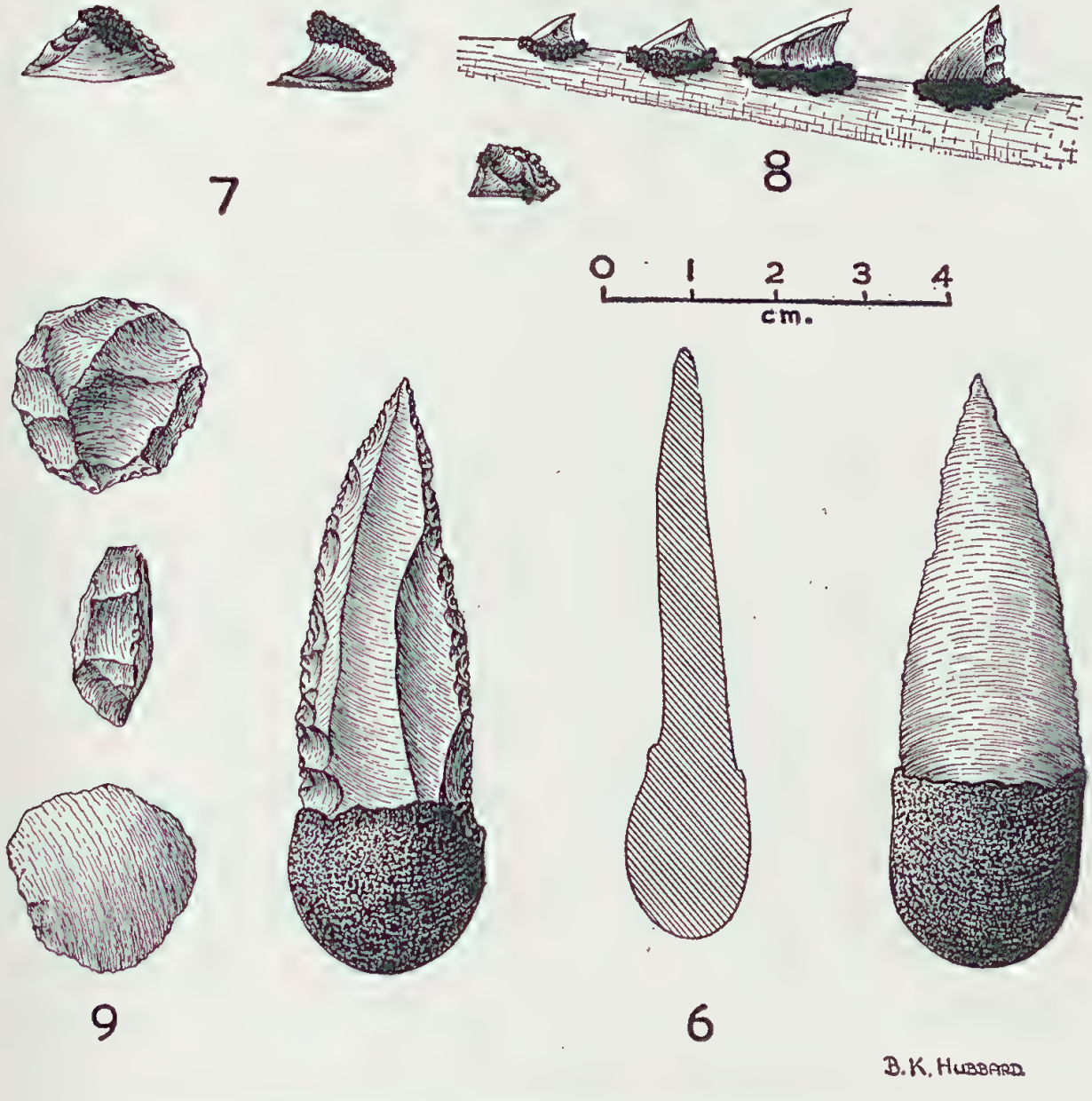
During the years after 1930 detailed physiographic studies were made in the Murray Valley and coastal South Australia with the hope of developing a time scale. These studies established that the Tartangan deposits were laid down prior to what is now called the Older Peronian (Three Metre Eustatic) Terrace, and were drowned and mineralized by changes in sea level affecting the river valley upstream beyond Tartanga. Indications that later climatic changes had occurred were developed in a series of eight papers (Tindale, 1931-1963). There was parallel work by Sprigg (1952), Hossfeld (1950) and others. Time scale of the succession of these happenings is now controlled by radiocarbon dates.

Since the first discovery of a culture succession on the River Murray the reality of it has been tested using many thousands of specimens from rock shelters, surface sites, from lesser excavations, and from test section controlled open sites. Some of the most useful information has come from isolated open sites occupied only during a single culture phase. A notable example is the exclusively Mudukian site situated on a former inlet of the Coorong at Policeman Point, South Australia. This site was occupied while sea stood at a height of between 1.5 and 2.0 metres above its present level. It was abandoned when the lowering of water level and a beach bar destroyed its advantages. Its implements are comparable with those of Mudukian levels in Devon Downs Rock shelter. A few key examples are given (Figs. 1-3).

The new data from many hundreds of sites confirms a conclusion that each of the cultural units at Devon Downs and Tartanga was widely spread in Australia. The sequence of the units is the same over wide areas, and the times of first occurrence in adjacent areas tend to be comparable. However it has become evident that there are time lags or gradients to be seen when the whole Australian area is considered. Thus a culture phase may linger, sometimes in modified form, in one area long after it has been replaced elsewhere. These gradients tend to be from north to south and from east to west suggesting that new cultural influences were tending to come from a generally north-easterly direction. Areas of culture lag are east of the Great Dividing Range, the more arid parts of the Great Western Desert, and on the uplands of the western Northern Territory where, to take an example, Pirrian styled projectile points are still used in a variety of ways. The knife shown in Fig. 6 and the well known hafted unifacially worked stone spears are from this area. There is a culture lag also in the Kimberley Ranges in north-western Australia. In south-western Australia the last phase of the

Mudukian culture had not quite ended at the time of the coming of Western civilization, as evidenced by a few modern survivals of geometric microliths characteristic of that phase (Figs. 7-8).

Excavations at Fromm Landing by Mulvaney (1960) confirmed the succession at Devon Downs from the present day down to an early Pirrian



FIGS. 6-9. PRESENT-DAY AUSTRALIAN IMPLEMENTS AND AN ARCHAEOLOGICAL ONE

Fig. 6. Pirri point hafted with resin as a knife, Barrow Creek (A.4164); similar specimens are known to be made and traded south from the upper Victoria River, Northern Territory. *Fig. 7.* Three of a set of eighteen geometric microliths, in glass, from Western Australia still retaining blackboy tree resin of haft (A.2356), collected through Sir Edward Stirling. *Fig. 8.* Four of the same set restored to hafted position as indicated by resin surviving on the specimens. *Fig. 9.* Discoidal microlith from Pirrian Layer viii, Devon Downs Rockshelter (A.29193); it appeared first as photographic figure 193 in Hale and Tindale (1930).

level. The small incongruities he found are the historical consequence of the sites being 20 miles apart on opposite sides of a large river and therefore likely to have been occupied by different persons and families, with individual habits and behaviour patterns. They had access to different sources of implement stone. Mulvaney's second excavation, in a shelter only a hundred yards away from his first presented far greater differences and at first sight these seemed very strange. In the living culture however, the differences found in his two sites are of the kind that distinguish a woman's cooking camp from a residential area frequented by men. Some details are given in a later paragraph.

Direct comparisons of cultural material from Devon Downs and Fromm Landing material show that layer by layer resemblances are impressive and the association between geometric microliths and the Mudukian culture phase is clear, although the significant role of these small implements was not apparent when the *muduk* implement was chosen by Hale and Tindale (1930) as a marker for it. At that time geometric microliths as a type had not been well recognized in Australia. Nevertheless excavations at Devon Downs recovered nearly as many as were revealed at comparable horizons in the Fromm Landing excavation. Several of these Pirrian and Mudukian microliths from Devon Downs are figured here (Figs. 9-12). They include some recorded in the original report only by photographs and not adequately noticed by Mulvaney (1961: 79 and 84) and later considered to be absent from Pirrian layers (Mulvaney 1963: 43). Significant specimens from some other Mudukian sites are illustrated for comparison (Figs. 13-14).

The Multi-cultural Concept

In recent years names for archaeological culture phases have multiplied and others may be added since the results of any excavation are likely to show some differences and there is perhaps a temptation to reduce the status of earlier concepts so that the new finds may be given significance.

Certain pertinent facts, based on information available from living aboriginals may give perspective and prevent undue proliferation of archaeological culture terms, and yet allow recognition of the existence of valid local differences. Some of the differences are a matter of livelihood. In some areas hunting dominates over fishing activities; desert-versus rainforest-dwelling encourages different habits; mallee scrub living when compared with sandhill dwelling is apt to show unlike patterns since people who live on water from the roots of trees have no settled living places. Other differences are historical—some peripheral communities retain material culture traits seemingly out of phase. Sometimes they are casual local survivals of older implement types superseded elsewhere.

Up to the present only three living culture phases have been named in Australia, the Murundian generally over Australia and particularly in the west of the Murray-Darling Basin, the Kimberleyan in north-western Australia and the Milingimbian in Arnhem Land; the last named was considered by McCarthy at first to be Murundian. A fourth and a fifth culture grouping probably can be recognized, one in the Western Desert where very old implement styles survive and the other in the Torres Strait Islands, where a relatively late intrusive group is living. The Kimberleyan may be a post-climax survival of the Pirrian Culture in which the chief marker implement, the *pirri* projectile point, has been developed by additional work into a biface pressure-flaked implement, as happens each time a new Kimberleyan point is being manufactured. In support of this conclusion archaeological *pirri* implements may be found in the sand directly underlying the present day camp debris at Moolabulla (noted during field work in 1953, when the whole process of pressure-flaking of Kimberleyan points was observed and filmed for the Djaru and Kitja peoples). Further east on the central plateau of the Northern Territory and in the upper Victoria River area *pirri*-making survived as it did also into the 19th century in the area near Lake Waukarlykarly in Western Australia.

In coastal Victoria microlith users may have continued their work almost until modern times. Thus they were very close to the Mudukian/Murundian transition and it may be correct to suggest in south-western Australia that we are seeing a very late phase of the Mudukian. Since the drawings for the modern glass microliths shown as Figs. 7-8 were prepared, Mr. K. Akerman has found similar microlith implements also made from glass, on a campsite at Walyunga, Western Australia. His suite of implements shows much of the character of a Mudukian series.

Both McCarthy and Tindale have argued that the edge-ground axe is a late cultural acquisition, that spread quickly in Australia. Wherever its use would be of advantage it was adopted but rejected in treeless sand deserts and in other places where it was without function. One of its principal uses was in the search for *Trigona* honeybee nests in hollow trees (Tindale 1966).

Study of the types of stone axes originating in the igneous rock quarries in the Cloncurry district of Queensland has been useful in giving an understanding of the way culture change went on in Australia with the appearance of the edge-ground axe. The evidence for spread of this particular axe is clear, since the type of stone is highly characteristic, and the source is unmistakable. There is no other basaltic outcrop within a radius of over 400 miles. Archaeologists find two main types, the flaked-and-edge-ground variety and the flaked, hammer-dressed-and-edge-ground type. At the time of first European contact the hammer-dressed type was

still being distributed southward and eastward and west along well recognized trade routes, the other type had been superseded. Thus all known authentically hafted axes of Cloncurry stone are hammer-dressed ones.

The hafted edge-ground axe and its known successor, the hammer-dressed variety, were acquired by Murundian culture users as late innovations in the Lower Murray Valley, without a major culture change taking place. I consider Murundian culture users as *advanced* where the new implement has been accepted because it was a boon, and others as *retarded* where it was of little use and not generally adopted. In between were some transitional areas such as west of the Murray River in South Australia where the incentive to use axes was limited, the mines far away and axes so scarce that over a century of gleaning has revealed fewer than half a dozen archaeological axeheads (Tindale 1933, 1936). In contrast an area of about equal size east of the River, particularly in the well-wooded south-eastern area of South Australia has yielded several thousand archaeological examples of edgeground type. In addition a dozen hafted examples have survived to show they were in use in the living culture. Some of the difference between *advanced* and *retarded* Murundians can be ascribed to remoteness of sources of supply of types of basaltic rock preferred for hafted axes. Barriers to trade imposed by a schism, like that between circumcising— and non-circumcising tribes-people may have helped to prevent the later day westward spread of the axe.

The trend of evidence indicates a measure of cultural unity over large areas in Murundian times.

However, let us consider the possibility of an extensive fragmentation of the living Australian cultural scene. Subdivision might be made in several different ways. A sample list could include:—

Coastal people of the Northern Territory;
Inland people of Arnhem Land;
People of the Kimberley Ranges in Western Australia;
South Western Australians, the *-up* people;
South Western Australians, the *-ing* people;
The non-circumcizing people of the West Coast of Western Australia;
Western Desert peoples;
Canning Basin peoples;
Central Australian tribes—people east of the Aranda/Kukatja boundary;
Cape York Peninsula people;
North Eastern Queensland—the rain forest tribes-people;
North Eastern Queensland—the dry forest and grasslands people;
Murray-Darling Basin tribes;

Western Queensland tribes;
Coastal New South Wales tribes;
Gippsland people;
Tasmanian aborigines.

To these 17 major groups one might add smaller groups such as the isolated Kaiadilt of Bentinck Island, the Tiwi of Melville Island, the Djaui of Sunday Island and the Bidawal of the mountains of the New South Wales-Victorian border. These 21 groups may have some pretensions to differentiation.

A further degree of subdivision, if considered necessary, might involve the tribal one, of the approximately 650-700 discrete tribes present in Australia.

Whatever type of framework we might seek, there is not sufficient data to differentiate material culture trait blocks on a tribal basis, even when all perishable material is taken into account. One might be hard put to define living material cultures even in terms of a score of regional types. It would not be possible to proceed thus far, particularly if actual stone remainders of present day tools only and similar imperishable objects could be taken into consideration.

Working from the known to the unknown it is clear there is room in present day Australia for only a few concurrently functioning cultures; perhaps only for a single culture, with peripheral late survivals from one or more earlier ones, namely the traces of the microlith-using peoples in several places, the peoples in the Western Desert who use *jimari* knives of Tartangan and Tasmanian form, the pebblechopper users along the Queensland coast (Jackson 1939), the Kimberleyans, and of course the Tasmanian aborigines.

Within the small number of cultures which we can postulate with a measure of certainty there may be recognized a somewhat greater number of local industries, reflecting different economies and determined by the use of different local varieties of stone, each with its own special characteristics and capacities for use, sometimes demanding local adaptations in modes of hafting and handling such as the use of animal skin bindings in place of resins in some areas of Queensland. Clear differences exist between the industrial habits of Walpiri and Pintubi men and suggest that these may reflect long-standing differences in tool-making techniques between Central Australian and Western Desert peoples (Tindale 1956). The fist axe users of the islands of the Gulf of Carpentaria also retain anomalous tools and tool using techniques. Any given industry tends to spread however over a wider area than a single tribe, for not every area is equally blessed with a source of supply of raw materials and the material from any one mining area is likely to have travelled many miles to its users. For example

Kimberley biface spear points may become circumcision knives after having been traded for a distance of upwards of 600 miles in a southerly direction (Tindale 1965).

Let us try and make a case for as many discrete industries as possible, using as a test area that occupied by the 60 tribes living in the Murray-Darling Basin. Using all aspects of culture including language we might differentiate fewer than half a dozen distinctly different units; using material culture items alone, perhaps no more than a single unit. The major distinction is that in one-half of the area the spearthrower is not used. Thus there are no bone spearthrower pegs to become part of an archaeological record. This situation would not be greatly improved if we used only the stone and bone remainders of implements in developing our analysis of the situation. Within the one industry there is a gradient, northerners possessing quality stone axes. Edgeground stone chisels are uncommon in the south.

In Australia there is in general direct physical contact between tribes to the extent of approximately 15% intermarriage (Tindale 1953). Sharing a common riverine environment and material culture as they do this degree of contact ensures that cultural novelties would be rapidly transmitted about the Murray-Darling Basin. Any new implement type soon would become common near any place of manufacture, with a gradient away from this source.

Transects across the Basin in several directions cut through a maximum of eight tribal areas, and because the Kamilaroi and the Wiradjuri are wide-ranging, a line through their territories would be only four tribes long. Ideas and practices evidently would become common property in a relatively few generations.

Thus if we study living peoples we are in a better position to assess the archaeology of an area. I quote an example where this type of evidence has been a help in making a correct assessment. It relates to the culture phase called Tartangan. Mulvaney (1961) raised objections to the use of implements of similar types from Noola, Lake Menindee, Devon Downs and the South-East of South Australia to confirm the existence of a common Tartangan type. Similar ones have now been found at Kenniff Cave in Queensland and at Keilor in Victoria. The objections were trivial and now seem even less valid since intermediate archaeological sites have become available and disappear when consideration is given to the close relationships existing between the living peoples who replaced the Tartangans.

I have already referred to the marked differences encountered by Mulvaney (1960 and 1964) in archaeological evidence from two adjoining shelters at Fromm Landing. Very obviously these cannot be interpreted as indicating the simultaneous presence of two industries. When living people

are consulted (and there is one aboriginal person still living who in his childhood days camped at both Fromm Landing and Devon Downs) a likely explanation is forthcoming. Cooking fires and the gathering places for women are at a little distance from places where men tend to congregate.

Milerum, the last of the Tanganekald of the Coorong, who spent his childhood in the bush, also has described women's camps to me. The women of his tribe were forbidden to handle stone for cutting purposes. For such work they depended chiefly on sharp edges of mussels and on knives made from solid *Eucrassatella* valves. Their only other implement was the edge of their thumbnail which, from constant use and periodic sharpening became thick and strong; it served in trimming basket reeds, opening fish and in scraping roots. Under such circumstances women's cooking fire hearths would yield quite different archaeological traces than would those occupied by males.

Bearing in mind the long Murundian tradition, of at least two millenia in the Lower Murray Valley, it seems clear to me that the absence of all but mussel shells, scarcely distinguishable as knives when discarded in places where many others are being cooked in fires, is a clear indication that the use made of the southern rock shelter at Fromm Landing was that of a women's camp.

NOMENCLATURE OF CULTURES AND INDUSTRIES

A sound system of nomenclature, preferably based on priority seems desirable to solve the nomenclatorial contradictions developing among Australian workers in prehistory. Part of the misunderstanding which exists may be based on differing interpretations of the role of the terms *industry* and *culture* in the naming of archaeological units. These are not synonyms.

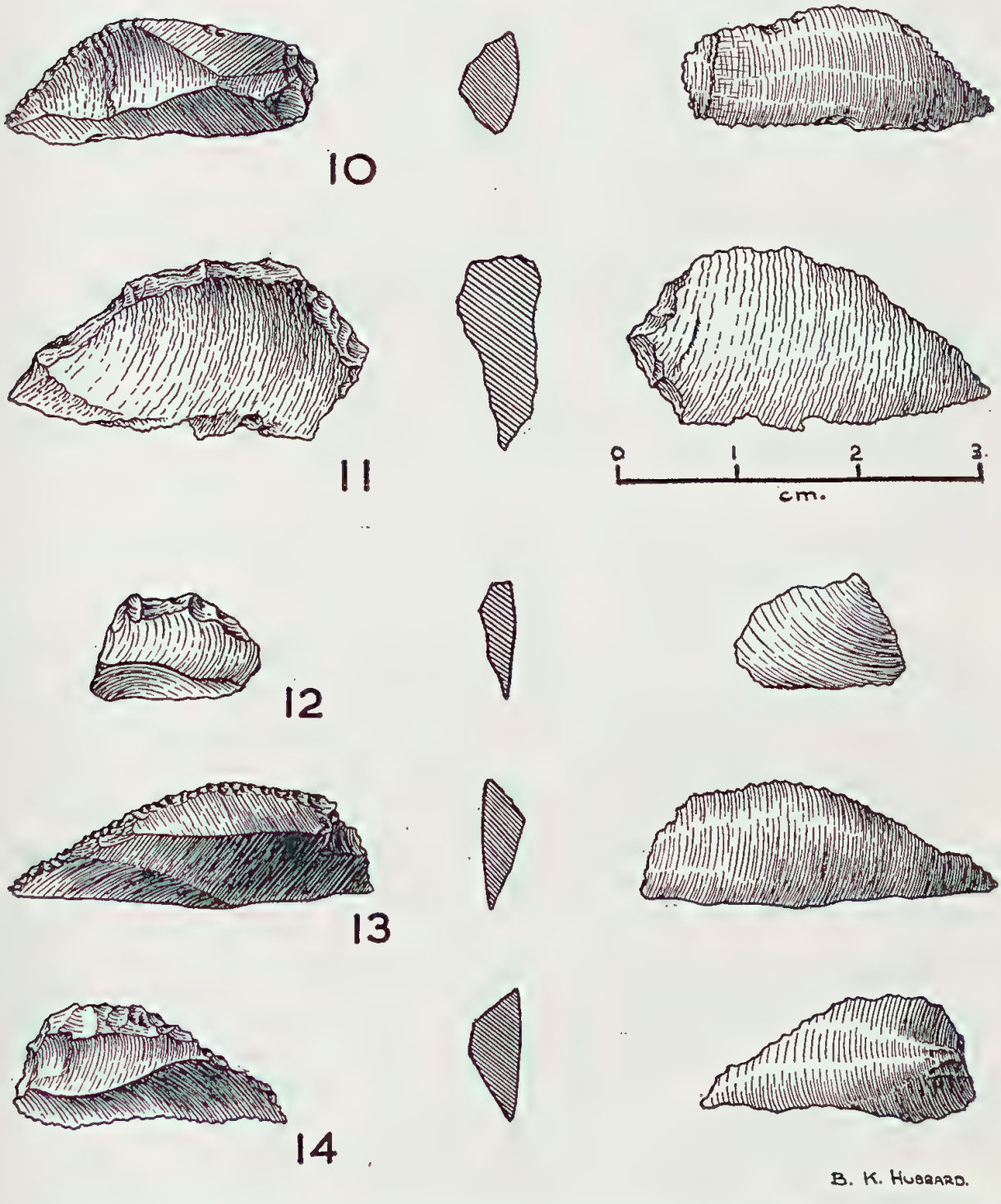
An archaeological culture is named from a specific suite of implements or other relics. Spatially and temporally it preserves a common facies or character, suggesting an underlying unity; it tends to be widespread and is a major unit. The relics which denote it may appear at a given place either through migration or evolution. A culture may persist for a long time, sometimes measurable in thousands of years; it matures or wanes and ultimately either disappears or is replaced by another. By culture contact and by mutation it may change into another newer one. If we had perfect knowledge of history, the whole process in any one place would seem like a flowing stream of events. Breaks in sequence, sometimes caused only by deficiencies in the archaeological record, enable development of a nomenclature for the principal preserved sections. In the living cultures we can

see stages in these changes as if they were clines, for example the changes in Australia due to the coming in of edge-ground axes mentioned earlier in this paper.

The term *industry* is used with a somewhat more local significance. Within a given area local differences can be detected, based on the exploitation of differing classes of raw materials. For example pebbles instead of angular blocks of stone. Matthews (1966) gives an interesting example of this difference. Differing local demands, following dependence on locally varied economies may lie behind differences in industries. Sometimes the effects are merely seasonal due, for example, to the exploitation of a seashore area in summer and an inland one in winter, with differing needs in tools and varied activities at two seasons. A series of industries can be contemporaneous and fall into a common culture phase. Among living people we can see fisher-folk along rivers living near inland kangaroo hunters; shore-dwellers and desert-frequenters; mallee scrub nomads and sedentary exploiters of rain forest areas have differing needs. A series of industries therefore are the local and contemporary expressions of a wider single culture phase. Each industry is removed from the next in space, but is linked by the possession of underlying similarities indicating cultural unity.

In an analogy with zoological terms a *culture* would correspond to a *species,* an industry would be a *local race.* All the local races together comprise the species and following zoological practice the first named race becomes the nymotypical one. It does not have to be the most characteristic or common one, for this may not be determined and appreciated for many years after the initial discovery and naming of the species.

A specific example may now be given where confusion between culture and industry has led to difficulties. There is in Australia a widespread culture whose most characteristic stone implements are microlithic crescents and other geometric forms. It was first recognized at Devon Downs, where it is rather impoverished, because of the local paucity of good stone for implements. It was named the Mudukian Culture. This name has priority. It occurs also at Fromm Landing. There are other sites near North West Bend, and an even richer suite has already been mentioned from Policeman Point, South Australia (the Policeman Point Industry, to give it a name). Along the east coast it reappears as the Bondaian Industry and it appears also with similar suites of implements at intermediate places. I list Blundell's Valley, near Canberra and show a specimen (Fig. 5), Mornington Peninsula, Victoria (Fig. 13), and Noola near the headwaters of the Macquarie River, New South Wales. Most of the implements of this Mudukian Culture reappear in other parts of Australia. There is a good site, with many particularly fine specimens, some made from difficult-to-work quartz crystal, at Halcombe Creek, north of the MacDonnell Ranges



FIGS. 10-14. MUDUKIAN AND PIRRIAN MICROLITHS FROM DEVON DOWNS ROCKSHELTER AND ELSEWHERE

Fig. 10. Bondi type microlith from Pirrian Layer viii, Devon Downs (A.29198); it appeared in photographic figure 198 of Hale and Tindale (1930). *Fig. 11.* Broken crescent microlith in quartz, Mudukian Layer vi, Devon Downs (A.29019); not figured in original report. *Fig. 12.* Crescent microlith of chert from native mine near Berri, from Mudukian Layer vi (A.29043); not figured in original report. *Fig. 13.* Mudukian microlith of *bondi* type, Cape Schank, Mornington Peninsula, Victoria (A.51337), collected by Miss U. S. Teague. *Fig. 14.* Mudukian microlith of *bondi* type, Murramurang, New South Wales (A.51280), collected by Miss U. S. Teague.

in Central Australia. Prof. J. B. Birdsell found sites with characteristic *bondi* points associated with other geometric microliths in the Kalgoorlie area of Western Australia. Approximately 200 places are listed in the records filed in the South Australian Museum indicating the presence of the microlithic implements of the Mudukian Culture. They are present in all of the Australian States. It is probable that when local differences are evaluated many of the suites of implements can be given local names as industries, since the people who used them must have had different economic backgrounds and I think that local styles can be detected. Yet underlying unity of form and suite must bring them together as local expressions of an overall Mudukian Culture.

Microliths first appear in the Pirrian culture phase, but their great period of elaboration is in the Mudukian phase where they are dominant, and serve as convenient marker implements.

FUNCTIONS AND RECORDING OF ARCHAEOLOGICAL IMPLEMENTS

A fixed nomenclature for archaeological implements is desirable and should be developed, as far as possible on the basis of priority, leading to a stable nomenclature.

In developing a nomenclature for Australian archaeological implements one must take into account the almost unique situation we have in which our archaeological specimens can be linked directly with observations on similar ones being made and used by living people. Archaeologists therefore should not insist on any artificial frame of reference or on any concept which does not take into consideration data on the living, recognizing that they are likely to be cognate. There are a few types for which a living example has not been identified but these may well be fitted into gaps in the range of types since in any given area it is reasonable to expect certain basic functions to be performed with stone tools at hand. Thus there are tools used for chopping, scraping, cutting, piercing, wedging off, pressing, heating, ironing, hammering, abrading and milling.

Some people relegate archaeologically discovered artefacts whose function is not immediately apparent to a class called "ceremonial". In most instances in Australia further information has revealed a positive tool function for such implements. An example of such a discovery is the *ooyurka* (ujurka), which is warmed near a fire and used in the making of composite spears as an ironing and smoothing tool for resin joints and splices. The reniform slate tools once claimed to be "ceremonial" are skin flensers, and the interesting high-backed discoidal scrapers for which no apparent function could be suggested, were shown to be chisel stones when

Prof. J. B. Birdsell observed one in use near Balgo, in North Western Australia. It had been set in resin on the end of a stick. He saw the specimen in the act of its being removed and discarded in favour of a fresh stone, and retrieved it. It is now in the South Australian Museum collection.

Archaeologists should recognize that every stone tool may have a variety of uses in addition to its principal one. Besides its well advertised role as a knife and adze has anyone visualized the *kandi* stone on the handle of a Western Desert spearthrower as being on occasion, a toothpick? It may also be replaced in a few localities. Thus among hunting boomerang users in the area north of the MacDonnell Ranges the fire-hardened and deliberately sharpened proximal end of the boomerang may take the place of the stone of the spearthrower for the purpose of opening the belly of game animals when extracting the intestines. This may account for the lessened frequency of occurrence of *tula* and *kandi* on some archaeological sites north of the MacDonnell Ranges. (It is to be noted that while never reported many North American Indian boomerangs, the so-called rabbit sticks, have this same knife-like feature.)

It is the duty of students of the living cultures to describe, figure and record as far as possible with exact aboriginal terminologies, all tools, processes of uses and manufacture and all ideas associated with implement utilization. A worker should neither be expected to force his observations into archaeological terms, nor have to conform to any system to which there are valid objections. He should describe and define his type specimens and illustrate them in good detail, with all possible terms and names associated with them, as objects of living culture.

Early reports on implements, sometimes derived from the accounts of the original explorers, often are casual and may be in more than one language. If a system of priority is adopted for archaeological nomenclature two questions arise immediately—(*a*) Should non-English terms be adopted when they have priority and (*b*) should there be a time limit?

Zoologists give us a precedent. They use a specific edition of the work of Linnaeus in 1767, as a starting point for their system of priorities in zoological nomenclature.

Possible starting points for an Australian archaeological implement naming system are the year of Captain Cook's landing at Botany Bay or the Conference on methods of recording arranged by the Governor of South Australia, Sir George Grey, at Adelaide in 1841. If a more modern date were considered it would be desirable to include the observations of Carl Strehlow, of Walter E. Roth, and Spencer and Gillen; this would require a starting date before the end of the 19th Century.

Implements similar to those found in Australia have been named from other parts of the world. It is a point for debate as to how far these terms might be applied in Australia. A case for a local term, rather than an introduced one, even of prior date would be strong if the Australian term reflected observations based on the living culture, rather than the dead.

Some of the earlier sources are not of high merit and there are some difficulties in deciding what is a recognizable type of publication. While some old original sources should be recognized, it may be desirable to set standards for the future. Many sources are available.

Formal reports with adequate illustrations.

An example is the excellent technical description of the *lamma* implement by Roth; this has tended to be overlooked in favour of *tula.*

Less formal reports with or without adequate illustrations.

Reports in magazines and travel books.

Printed record cards, distributed to those interested.

South Australian Museum record card, 1937 to date (Fig. 15).

Reports in newspapers and other ephemeral publications.

Much primary data in Australian ethnography is preserved only in such sources. An example is Falkinder's report in the *Sydney Morning Herald* of 14 June 1930, recording archaeological finds of what he calls Tasmanoid types in New South Wales, with a proposed terminology based on Tasmanian words. No more formal record has ever been published.

Research motion picture films.

There are 50 published 16 mm. films of the Board for Anthropological Research, University of Adelaide (1930 onwards) in which many implements are illustrated in use. These are used in teaching at Universities in many parts of the world and their names are already widely known.

Printed labels displayed in and sometimes circulated between Museums.

Unpublished communications between researchers.

Should old journals and correspondence in State Archives be accepted?

A stable nomenclature can be assured only if an implement is accurately described, with a type specimen which is figured so that it can be recognized. The name itself, if of aboriginal origin, should be transcribed in some recorded phonetic system. An approximation to this should be capable of being printed in standard works without use of special

type. Since 1941 the Geographic II system has become mandatory in transcriptions of non-traditional place names in the United States, England, France, Canada and I believe also in Australia.

Technical terms are necessary in the description of a stone implement, and its proper orientation is of the utmost importance if a sound description is to be given.

Earlier workers tended not to use any fixed orientation. In Australia it was the late H. V. V. Noone who first encouraged the development of a sound descriptive terminology. This system was first applied in a paper in the *Records of the South Australian Museum* (Tindale and Noone 1941).

ILLUSTRATIONS OF IMPLEMENTS

As early as 1926 many South Australian workers agreed informally to publish adequate illustrations of each object they described and avoid exclusively verbal description. Adherence to this voluntary agreement is manifest in many hundreds of illustrations.

Not all illustrations are satisfactory; too often one is left with the problem of determining the nature of the third dimension, and of deducing the appearance of the opposite face; in general it is often impossible to tell the difference between uniface and biface trimming because no mention is made of the side not depicted. From three to five views of each implement are necessary for a proper appreciatiion of its form, and a few such sets of illustrations are better than pages of description.

ARCHAEOLOGICAL COLLECTIONS

Mulvaney (1960) was critical of archaeological collections preserved in certain Museums. It should be indicated that such remarks cannot be applied to the collections in the South Australian Museum.

The specimens relied on in these studies have been carefully and accurately processed, numbered and labelled in English. There is systematically recorded data present for specimens from 2,393 sites, as determined by a count made in 1962. These collections include 74,499 specimens sufficiently characteristic to fall into recognizable implement classes according to the South Australian Museum Record card, of which a current sample is illustrated (Fig. 15). This five by eight inch card was first printed and distributed by the South Australian Museum in 1937 as a result of studies and enquiries made in Europe and America during 1936. The card enables a preliminary sorting of material from each site.

The Museum has reasonably large collections from Australian States other than South Australia and figures stand at: New South Wales (4,600 specimens from 264 sites); Tasmania (1,394 examples from 110 sites); Western Australia (4,574 from 196 sites); Queensland and Northern Territory (2,721 specimens from 248 sites); these are in addition to the very extensive series from South Australia (61,750 examples from 1,575 sites). The secondary material from each site, amounting in the aggregate to many additional thousands of lesser specimens, is kept apart for study of materials, especially for considering ratios of type of rock and for determining methods of manufacture.

Detailed listing of the specimens has been principally the work of Mr. Harold M. Cooper, Honorary Associate in Anthropology, who first volunteered his assistance in 1934 and since then has made the maintenance of these records part of a life's work, as well as a basis for his own outstanding studies on Australian stone implements.

Mr. Cooper also recorded specimens collected by members of the Anthropological Society of South Australia, by members of kindred organizations, and by other interested persons. Most of these auxiliary specimens have been marked and after noting returned to the finders. Many collectors have made the Museum the ultimate repository for such specimens.

Parts of this large collection have been examined, from one aspect or another by many members of the Adelaide school and by others, for example in papers by Campbell 1924, 1960; Campbell and Noone 1943; Campbell, Cleland and Hossfeld 1946; Cooper 1941, 1943 (two papers), 1947, 1948, 1950, 1954, 1959, 1960, 1961 (two papers); Cooper and Condon 1947; Davidson 1935; Edwards 1963, 1964, 1965; Hale and Tindale 1930; Harvey 1941; Howchin 1934; Matthews 1966; McCarthy, Bramell and Noone 1946; Mountford 1938, 1939, 1940, 1941; Noone 1945; Pretty 1962; Stapleton 1945; Tindale 1926, 1932, 1936 (two papers), 1937, 1940, 1941 (three papers), 1945, 1949, 1950, 1951, 1955, 1956, 1957 (two papers), 1959 (two papers), 1960, 1961, 1963, 1965, 1966; Tindale and Maegraith 1931; Tindale and Mountford 1936; Tindale and Noone 1941.

The South Australian collections are rich in specimens from the present-day culture, for in addition to the archaeological material, the hafted implement series available from the living may be far larger than present in any comparable collection. The late Sir Edward Stirling first, in the 1890's, then E. R. Waite made large collections and since 1921 we have specialized in bringing such material together in association with first hand observations on their use, derived from aborigines still employing or knowing how to use them. In this way the collection has more than trebled in size with ethnological objects of the living culture since 1921.

Site.....No. A.....Australian Campsite Period.....

Sect.....Hundr.....State.....

Owner.....Address.....

Sketch Plan

Scale

N

W E

S

Description of site

Sketch Section

Scale

No.	Date	Collector	Notes

Site No. A.

CHOPPING Cores
Cores .....
Sumatra .....
Pebblechopper .....
Karta .....
'horsehoof' .....
'coup de poing' .....
Pebble end .....
CHOPPING Flakes
Simple flakes .....
Kodja .....
Arapia .....
POINTS
Pirri .....
N.W.A. pressure flaked
Butted blade.....
Bondi/Woakwine.....
Microlith blades .....
Drills .....

CRESCENTS
'Newcastle' .....
Microlith .....
Elouera.....

AXES Edge-ground pebble
Ungrooved .....
Grooved .....

Percussion-dressed pebble
Ungrooved .....
Grooved .....
AXES Edge-ground flake
Ungrooved .....
Grooved .....

Percussion-dressed flake
Ungrooved .....
Grooved .....

KNIVES and SAWS
Abrupt-trimmed with—
Right handed flake.....
Left handed.....
Triangular flake .....
'woman's knife' .....
Pressure flaked dressed .....
Irregular chipped .....
Long blades.....

ADZE STONES
'Adelaide' .....
Discoidal.....
Discoidal (microlith) ....
Long (endscrapers).....
Endscrapers (microlith)
Double ended .....
Semi-biface.....
Concave .....
Nosed .....
Irregular .....
Edge ground .....
Worn .....
Slug (kandi)=burren....
Keeled Slug (tula) .....
Fire flints .....
Hammer stones .....
Upper mill .....
Lower mill .....
Rolling mill.....
Rasps .....
Slate scraper .....
Core.....
Miscellaneous.....

Marked stones
Tjurunga .....
Cylindroconical stones.....
unmarked .....
marked .....
Cornute stones .....
Incised stones .....
Throwing ball .....
Red ochre .....
Yellow ochre .....
Mn02

LIST OF FOOD REMAINS

FIG. 15.

Text of the obverse and reverse of the South Australian Campsite Record Card, in use since 1937. The original measures 8 inches by 5 inches.

THE ARCHAEOLOGICAL SUCCESSION IN SOUTH EASTERN AUSTRALIA

From a study of all the specimens listed in earlier paragraphs and the archaeological record there is an increasingly strong corpus of data to support the conclusion that the succession of cultures in South Australia and more particularly in the Murray-Darling Basin and its surroundings as far east as the Continental Divide, from at least 31,000 BP to date, will prove to be as follows:—

The modern cultures	Murundian	Present day to Peronian times	Probably with a time gradient so that cultures are later in time towards the south-east and towards the west
	Mudukian		
	Pirrian		
The older cultures	Tartangan	Pre-Peron Terrace	Modern times in Tasmania; extensively on the mainland from Late Pleistocene to Mid-Recent
	Kartan	Late Pleistocene	Kangaroo Island probably until Early Peronian times; present on the Bass Strait Islands

Each of these terms validly denotes a major culture phase in the sequence. The terms have many years of priority over any other ones which have been proposed.

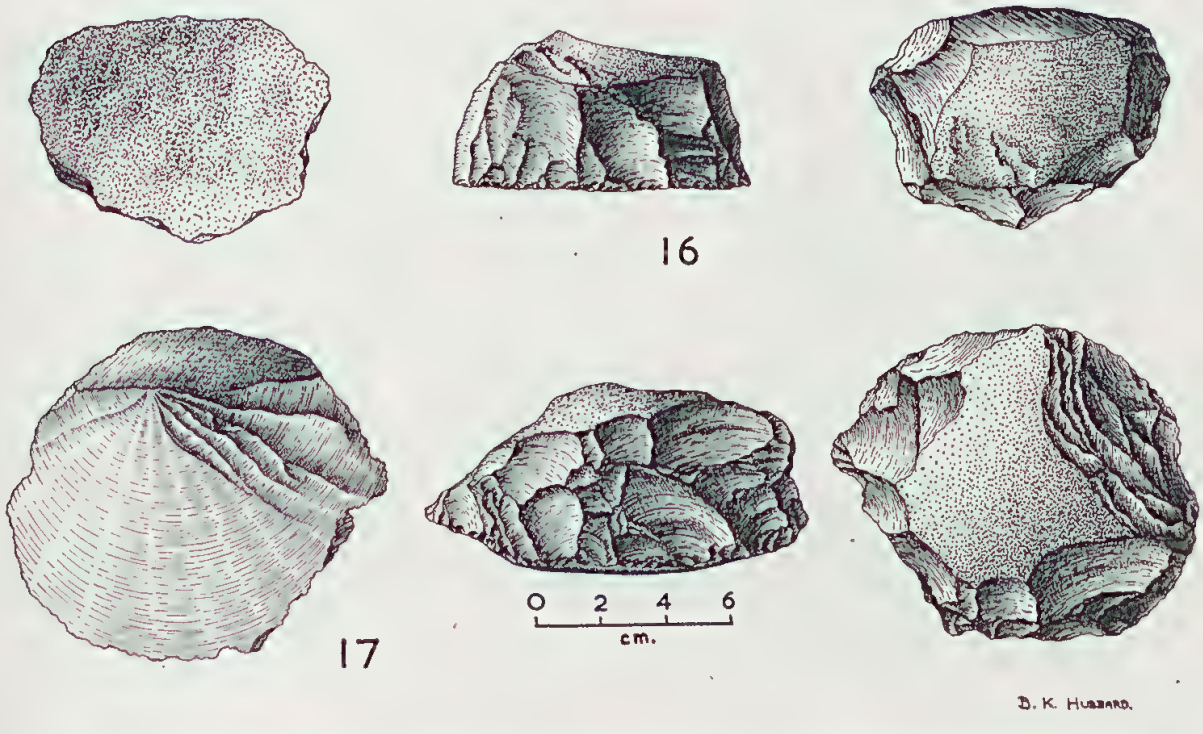
Radiocarbon dates have now been obtained from mass samples set aside during the excavation of the type site at Devon Downs in 1929. Others have been obtained from the Noola excavation. These support the above interpretation.

The Devon Downs ones enable clear cut time comparisons to be made with complementary results from Fromm Landing and elsewhere in the Murray-Darling Basin. They indicate that the transition from the Mudukian of Layer V at Devon Downs to the Murundian of Layer IV happened after 2980 ± 90 BP (GaK 2980). The Mid-Mudukian of Layer VII was at 3460 ± 100 BP (GaK 1022) and the Pirrian to Mudukian transition was after 4250 ± 180 BP (Lamont Lab.). At Fromm Landing the latest *pirri* occurred at 3740 ± 85 BP (P. 308). The Pirrian occupation evidently was intense and both Layers VIII and IX at Devon Downs have closely matching dates, that for Layer VIII, being formally given as 4360 ± 110 BP (GaK 1023). Mulvaney's date of 4840 ± 100 BP (R-456/1) for his earliest occupation with *pirri* implements at Fromm Landing is now confirmed by a date of 5180 ± 100 BP (GaK 1024) for Devon Downs Layer XI. This stratum was laid down prior to the beginning of the Pirrian in Devon Downs Rockshelter.

A date of 6020 ± 150 BP (L 271E) marks a late Tartangan horizon (Bed C) at the type site at Tartanga. Beds D and E, above it registered a rapid rise of sea level. This marked the onset of the Older Peronian (Three Metre Sea level) and also the termination of the Tartangan occupation on Tartanga Island.

Three related dates from Noola Rockshelter, in New South Wales, show Tartangan implements were present between 11,500 BP and a terminal date prior to 5320 ± 88 BP (V 36). A single Kartan type pebble side chopper, identical in form with classic side chopper ones from Kangaroo Island, occurred in the 11500 BP horizon. A definitive report on the Noola material is in preparation. This will discuss the detailed significance of three Late Pleistocene dates GaK 1025, V-35 and GaK 334 from Noola.

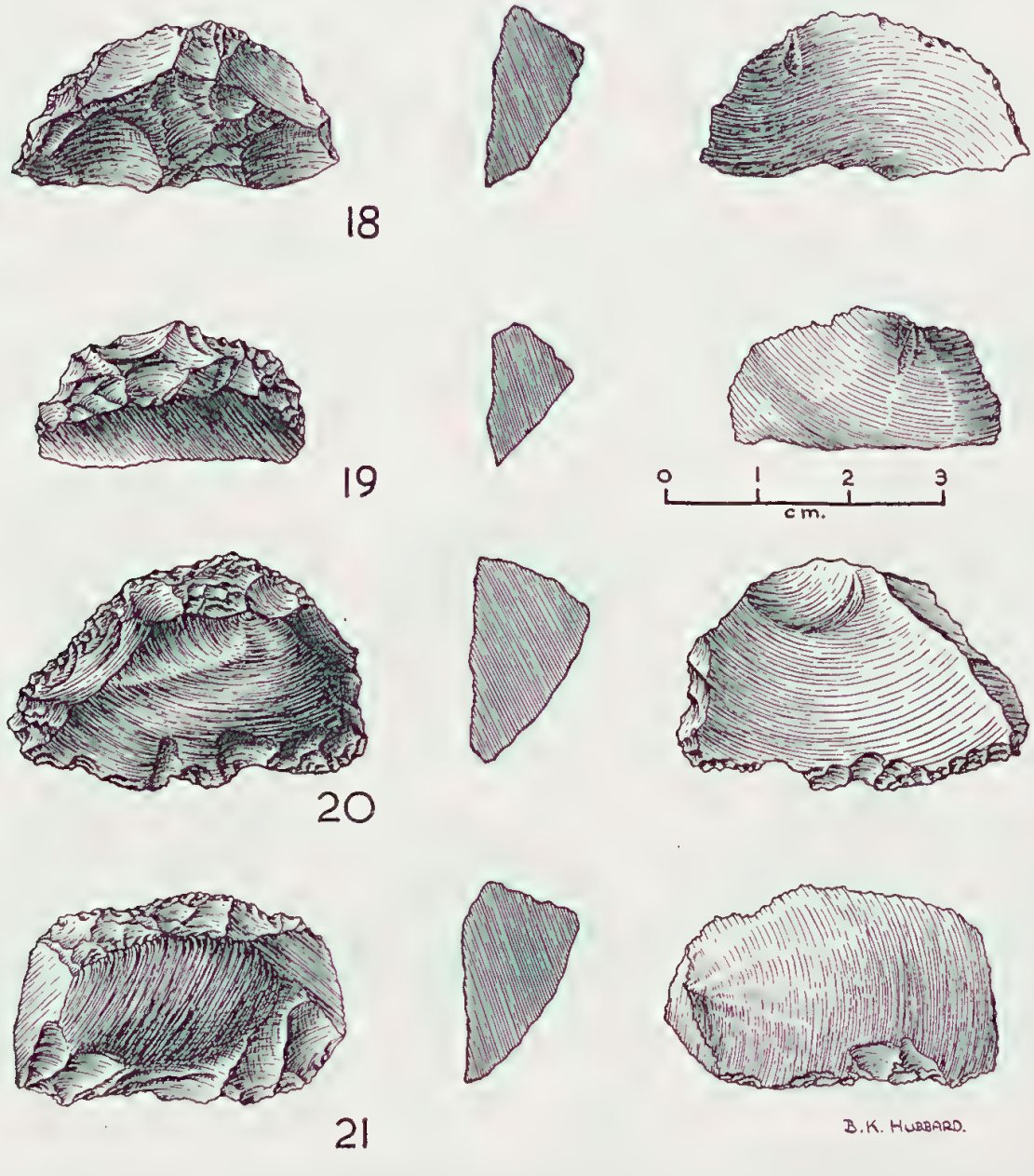
Unfortunately the record was confused when Mulvaney (1961) by an accidental reversal of facts considered that the specialized *arapia* implement, made on a striking platform like the *tula*, was present as the dominant type in the Kartan culture of Kangaroo Island, whereas in reality only *karta* implements, made on random blocks, and on large flakes are present. The



FIGS. 16-17. LARGE STONE IMPLEMENTS FROM KANGAROO ISLAND, SOUTH AUSTRALIA, OF THE KARTAN CULTURE.

Fig. 16. Three views of a *karta* implement from Hawk Nest (A.20430), made on a block without evident striking platform; all but one of the uniface chopping tools from the island conform to this type. *Fig. 17.* Three views of an *arapia* or *arapia*-like implement from Kingscote, 500 yards north of the town on top of cliffs, collected by H. M. Cooper, August, 1949 (A.30283); the prominent striking platform places it in the *arapia* class. It is the only *arapia*-like specimen found on Kangaroo Island and may be a pseudomorph.

more advanced *arapia* type is represented on the island only by a single example which is possibly only a pseudomorph. These two implement types are shown as Figs. 16 and 17. The error was compounded (Mulvaney 1963: 40, paragraph 3) and led to an untenable conclusion that the Kangaroo Island implements were different from ones on the mainland.



FIGS. 18-21. ELOUERA IMPLEMENTS FROM VARIOUS LOCALITIES.

Fig. 18. Upper Pirrian example from Layer viii, Devon Downs Rockshelter (A.29195); appeared as photographic figure 195 in Hale and Tindale (1930). *Fig. 19.* Woakwine Range, South-East of South Australia (A.28522), collected by T. D. Campbell. *Fig. 20.* Corunna Station *via* Port Augusta, South Australia (A.44920), collected by J. E. Johnson. *Fig. 21.* Bellambi, New South Wales (A.21165), collected by C. C. Towle.

When misunderstandings such as this are cleared up it is evident that the Kartan Culture is firmly established on geological grounds as of Late Pleistocene date in South Australia from sites at Fulham, Hallett Cove, the Wakefield River (interpretation of studies made by Cooper (1961)), at Port Augusta, and in the Flinders Ranges, as well as on Kangaroo Island. On Kangaroo Island the culture survived until just before the Mid-Recent. Implements were found *in situ* in a terrace deposit now identified as Early Peronian, at Rainy Creek (Tindale 1937). This section was re-examined and additional material collected in company with the late Prof. F. E. Zeuner. The importance of this section is re-emphasized. No implements of the Kartan culture have been found on Post-Peronian sand dunes despite a quarter century of searching during which Mr. H. M. Cooper added many sites to his formidable list from the island.

APPENDIX I—HISTORICAL NOTES ON SOME AUSTRALIAN ARCHAEOLOGICAL CULTURES AND THEIR MARKER IMPLEMENTS

Since the care of the archaeological collection at the South Australian Museum has now passed from my charge I feel that a few historical details on the growth of these collections would be in order here.

Early Activities

The first archaeological excavation made by me was in a shell mound at Yetiba near the mouth of the Emerald River, on Groote Eylandt, in early 1922. Assistants and interpreters of evidence were men of the Ingura tribe. (Another name, supplied by a later generation of men, has come into vogue for these people, namely the term Wanindiljaugwa. This is a valid name of only one of the principal hordes of the tribe.) These men were then meeting white men at close quarters for the first time and must have wondered at the purpose of such a proceeding. The results of this dig were enlightening chiefly as supplying me with details for the appreciation of the living culture.

The beginnings of systematic archaeological excavation in Australia have been described by Mulvaney (1957, 1961). He gives credit to work at Tartanga and at Devon Downs in 1929 as being the first definitive study (Hale and Tindale 1930). This study had been preceded by less productive exploratory work.

From 1924 onwards I had made small excavations and surface collections at Pedlar Creek, now called Moana, south of Adelaide (Tindale 1926). Work at this site has continued to the present day with detailed results which have been utilized in the interpretation of results at other places, but have not yet been published. In 1928 several sections were dug on a property near Como on the St. George River, New South Wales and sections were noted by me at several coastal sites along the ocean shore east and south of Botany Bay. Sites at Como and Boat Harbour yielded evidence for a Post-Glacial eustatic marine terrace; the significance was then little understood. Recent visits to the sites confirm that there are Peronian Terrace associations and that the camp-sites are younger than that event.

In the late twenties, Mr. Harold Sheard and I examined several sites along the River Murray, and among these we dug a shallow trial trench at Fromm Landing, where Mulvaney and others have since dug more deeply and with such useful results.

None of these excavations prior to 1929 had given evidence of any succession of culture phases, although in retrospect it can be seen that unpublished results from Fromm Landing run parallel with Mulvaney's findings. Our excavation went down into a layer which I consider now to be Mudukian, but the small yield did not allow us to see that we had passed into an earlier culture phase. Fallen rocks and limited resources discouraged us from going deeper.

Post-1930 Work in South Australia

In 1932 some 80 rock shelter sites were visited in company with the late B. C. Cotton, the then Conchologist of the S.A. Museum. A journey was made by a small launch from Murray Bridge to Blanchetown. Many sites were drilled to rock bottom with a posthole

borer. This instrument could be extended to reach a depth of 15 feet. Smoke-blackened cliff faces led us to several important sites. These remain to be excavated when further detailed studies are considered to be desirable in the Lower Murray Valley.

The Tartanga and Devon Downs discoveries led to detailed studies on the climate, history and physiography of the lower Murray Valley, and of the coastal shorelines to the south. The then prevailing ideas of the faultline nature of local shoreline development were challenged and ascribed to the effects of eustatic changes in sea-level (Tindale 1933, 1936, 1937, 1941, 1947, 1949, 1952, 1953, 1954, 1955, 1957 (two papers), 1959 (two papers), 1962). Aboriginal occupational sites were linked with eustatic terrace deposits.

Radiocarbon dates now available for various Peronian and Abrolhos terrace phenomena confirm the results obtained by these eustatic terrace studies.

At Tartanga the dominant flaked implements found *in situ* are very much re-used examples of the same *jimari* types as are characteristic of the Tartangan of the South-East of our State, at Lake Menindee and at Noola, New South Wales. Their degree of wear reflects the relatively great poverty of the Lower Murray people because of absence of implement stone in their area, necessitating importations from the South-East, from the Mount Lofty Ranges and the Berri area upstream. Despite the presence of implements whose stone must have originated in these three areas Mulvaney (1961) was not then inclined to admit that any relationship could be traced between the Tartangan of the South-East at comparable dates and that at the original Tartanga Island site. He dismissed the term Tartangan on this ground. Lately he has used the term "Tasmanoid" for Tartangan Culture finds. Existence of sites in intermediate localities and of better specimens near native mines in the Berri area and many widely dispersed finds now cut the ground from under his argument for the restriction of the Tartangan to the one site on the Lower Murray River. The Tartangan of Cape Martin is now known to extend, with the same types of implements, to five other sites to the north, including ones being studied at Snapper Point, Five Mile Rocks, Three Mile Rocks, Burk Island, and in the Hundred of Kennion. Similar implement sites are also present near Swan Reach and two native mine sites are in the Berri district, one at Erawirung of Post-Tartangan times and the other seemingly not worked since Tartangan times, because these are the latest implement types present on the weathered surface of the workings. Surface finds are sporadically distributed throughout the Murray Mallee area.

At Tartanga pre-Peron terrace implements are all Tartangan, and they do not include *tula* which have been obtained only from the post-Tartangan horizons which overlie them with a disconformity. Misinterpretation of this led McCarthy (1957) into a baseless assumption that the Tartangan was a *tula* possessing culture and in his exhibit at the Australian Museum, Sydney, he shows a cast of the example figured as No. 39 by Hale and Tindale (1930) from the surface of an Upper Bed, as if it were Tartangan.

At Tartanga only the Post-Peronian beds (G, H and I) yield *tula*. The one mentioned above (Fig. 39 in original report) is a classic example of a much re-used *tula* made from a particular ruby-coloured chert which is now known to have originated in the native mine at Erawirung. It should be on record that this mine site has been acquired by the National Trust of South Australia and dedicated as a national monument. The facts are clear that *tula* are indicators of the passage of the later waves of culture down the wide plains of inland eastern Australia from the north. In the lower Murray Valley they are of Pirrian and of later times.

In outlining recent history of work in South Australia mention should be made of other studies. At a road cutting in the Hundred of Noarlunga a site has been found where aborigines exploited *Brachyodontes* and other estuarine shells. These appeared in the estuarine valley of the Onkaparinga River as soon as its tidal reaches were drowned by the rise of water level which accompanied the occupation of the Older Peronian eustatic terrace. A well defined foodshell-containing horizon marks the beginning of a Mid-Recent occupation and is dated by Prof. K. Kigoshi (GaK 674) as at 5820 $\pm$ 90 BP. Kartan Culture implements were unearthed from the yellow, slightly indurated sand which underlies this horizon with an unknown hiatus in time. The occupational debris above this horizon is Pirrian and younger.

At Pine Dam on the eastern side of Lake Torrens charcoal from a Pirrian horizon, has been dated at 1860 $\pm$ 110 BP (GaK 675), indicating the possibility that the Pirrian culture, which in the Murray Valley was replaced by the Mudukian culture phase around 3800 BP lingered longer in the area to the west. As elsewhere it is overlain by beds containing horizons in which occur geometric microliths of well developed forms.

At Burk Island, in the Hundred of Symon, a cattle property inland from Beachport, South Australia, a single pebble side chopper of transported basaltic stone was unearthed while digging into a dark clay at a depth of 5 feet, during the making of a stockyard. The find was made by the owner, Mr. T. McCourt. Surface material on the rise of Burk Island is chiefly of Tartangan types. Isolated finds of this type often point the way to important discoveries and suggest that a Kartan horizon may underlie the Tartangan of that area.

APPENDIX II—REFERENCES

(The numbers of figures of implements quoted are for originals only)

Campbell, T. D., 1924: *Trans. Roy. Soc. S. Aust.*, Adelaide, 48: 74-78 (3 original figures of implements).

———— 1960: *Rec. S. Aust. Mus.*, Adelaide, 13: 509-524 (7 figures).

Campbell, T. D., Cleland, J. B. and Hossfeld, P. S., 1946: *Rec. S. Aust. Mus.*, Adelaide, 8: 445-502 (4 figures).

Campbell, T. D. and Noone, H. V. V., 1943: *Rec. S. Aust. Mus.*, Adelaide, 7: 371-395 (117 figures).

Cooper, H. M., 1941: *South Aust. Naturalist*, Adelaide, 21 (1): 1-4 (3 figures).

———— 1943: *Trans. Roy. Soc. S. Aust.*, Adelaide, 67: 224-225 (4 figures).

———— 1943: *Rec. S. Aust. Mus.*, Adelaide, 7: 343-369 (96 figures).

———— 1947: *Mankind*, Sydney, 3: 292-298 (23 figures).

———— 1948: *South Aust. Naturalist*, Adelaide, 25 (1): 1-8 (8 figures).

———— 1950: *Trans. Roy. Soc. S. Aust.*, Adelaide, 73: 220-222 (11 figures).

———— 1954: *Rec. S. Aust. Mus.*, Adelaide, 11: 91-103 (26 figures).

———— 1959: *Trans. Roy. Soc. S. Aust.*, Adelaide, 82: 55-60 (22 figures).

———— 1960: *Rec. S. Aust. Mus.*, Adelaide, 13: 481-503 (48 figures).

———— 1961: *Rec. S. Aust. Mus.*, Adelaide, 14: 1-18 (29 figures).

———— 1961: *Trans. Roy. Soc. S. Aust.*, Adelaide, 84: 105-113 (18 figures).

Cooper, H. M. and Condon, H. T., 1947: *South Aust. Ornithologist*, Adelaide, 18: 66-68 (1 figure).

Davidson, D. S., 1935: *Journ. Roy. Anthrop. Inst.*, London, 65: 145-183 (45 figures).

Edwards, R., 1963: *Rec. S. Aust. Mus.*, Adelaide, 14: 515-524 (20 figures).

———— 1964: *Rec. S. Aust. Mus.*, Adelaide, 14: 643-651 (6 figures).

———— 1965: *Rec. S. Aust. Mus.*, Adelaide, 15: 9-27 (6 figures).

Fairbridge, R., 1958: *Trans. New York Acad. Sci.* New York *II*, 20 (6): 471-482.

———— 1960: *Scientific American*, San Francisco, 202 (5): 70-79.

Hale, H. M. and Tindale, N. B., 1930: *Rec. S. Aust. Mus.*, Adelaide, 4: 145-218 (209 figures).

Harvey, Alison, 1941: *Rec. S. Aust. Mus.*, Adelaide, 6: 363-368 (14 figures).

Hossfeld, P., 1950: *Trans. Roy. Soc. S. Aust.*, Adelaide, 73: 232-279.

Howchin, W., 1934: *Stone implements of the Adelaide tribe of aborigines now extinct.* Adelaide. Gillingham & Co., v and 94 pp. (148 figures).

Jackson, G. K., 1939: *Mem. Queensland Mus.*, Brisbane, 11: 289-295.

Matthews, J. M., 1966: *Archaeol. and Phys. Anth. in Oceania*, Sydney, 1 (1): 5-22.

McCarthy, F. D., 1941: *Rec. Aust. Mus.*, Sydney, 21: 21-26 (27 figures).

———— 1949: *Rec. Aust. Mus.*, Sydney, 22: 1-34, 141-154 (10 figures).

———— 1957: *Mankind*, 5: 163-168.

McCarthy, F. D., Bramell, E. and Noone, H. V. V., 1946: Aust. Mus., Sydney, Memoir 9 (with bibliography).

Mitchell, S. R., 1949: *Stone-age Craftsmen*, Melbourne, 211 pp., 270 figures (original).

Mountford, C. P., 1938: *Vict. Naturalist*, Melbourne, 55: 144-146.

———— 1939: *South Aust. Nat.*, Adelaide, 19 (4): 12-14 (8 figures).

———— 1940: *Mankind*, 2: 336.

———— 1941: *Trans. Roy Soc. S. Aust.*, 65: 312-316 (14 figures).

Mulvaney, D. J., 1957: *Historical Studies—Australia and New Zealand*, 8 (29): 32-43.

———— 1960: *Proc. Roy. Soc. Victoria,* Melbourne, 72 (2): 53-85 (36 figures).
———— 1961: *Proc. Prehist. Soc. London,* 27: 56-107.
Mulvaney, D. J., Lawton, G. H. and Twidale, C. R., 1964: *Proc. Roy. Soc. Victoria,* Melbourne, 77 (2): 479-516.
Noone, H. V. V., 1943: *Rec. S. Aust. Mus.,* Adelaide, 7: 271-280 (28 figures).
Pretty, G., 1962: *Ann. Magazine Lincoln College,* Adelaide, 2 (4): 12-16 (5 figures).
Ride, W. D. L., 1958: *West Aust. Naturalist,* Perth, 6 (7): 162-179 (19 figures).
Sprigg, R., 1952: *Int. Geol. Congress 18th session,* 13: 226-237.
Stapleton, R. de S., 1945: *Rec. S. Aust. Mus.,* Adelaide, 8: 281-287 (9 figures).
Thorpe, W. W. and McCarthy, F. D., 1933: *Rec. Aust. Mus.,* Sydney, 19: 23-27 (33 figures).
Tindale, N. B., 1926: *South Australian Naturalist,* Adelaide, 8 (1): 10.
———— 1928: *Trans. Roy. Soc. S. Aust.,* Adelaide, 52: 223-224 (2 figures).
———— 1933: *Trans. Roy. Soc. S. Aust.,* Adelaide, 57: 130-142.
———— 1933: *in* Fenner, C. *Bunyips and billabongs.* Sydney, p. 151-152 (8 figures) (published previously by Fenner, in *Australasian,* Melbourne, 27 Dec. 1930).
———— 1936: *in Centenary History of S. Australia,* Adelaide (stone axe distribution).
———— 1937: *Rec. S. Aust. Mus.,* Adelaide, 6: 29-37 (6 figures).
———— 1937: *Rec. S. Aust. Mus.,* Adelaide, 6: 39-60 (7 figures).
———— 1938: *Trans. Roy. Soc. S. Aust.,* Adelaide, 62: 18-23 (1 figure).
———— 1940: *South Aust. Naturalist,* Adelaide, 20 (2): 26 (1 figure).
———— 1941: *Mankind,* Sydney, 3: 37-41 and 69-71.
———— 1941: *Aust. Journ. of Science,* Sydney, 3: 144-147.
———— 1942: *Pap. and Proc. Roy. Soc. Tasmania,* Hobart, 1941: 1-2 (1 figure).
———— 1945: *Queensland Naturalist,* 12 (5): 83-84 (1 figure).
———— 1947: *Rec. S. Aust. Mus.,* Adelaide, 8: 619-652.
———— 1949: *Rec. S. Aust. Mus.,* Adelaide, 9: 143-155 (climatic discussion) and 157-166 (6 figures).
———— 1950: *Rec. S. Aust. Mus.,* Adelaide, 9: 257-274 (10 figures).
———— 1951: *Rec. S. Aust. Mus.,* Adelaide, 9: 371-374 (2 figures).
———— 1952: Rept. Aust. and New Zealand Assoc. Adv. Sci., Sydney, 336.
———— 1953: *Rec. S. Aust. Mus.,* Adelaide, 11: 43-68 (climatic discussion).
———— 1953: *Human Biology,* Baltimore, 25: 169-190.
———— 1954: *Aust. Journ. Sci.,* Sydney, 228-229.
———— 1955: *Rec. S. Aust. Mus.,* Adelaide, 11: 269-298 (38 figures).
———— 1956: *Aust. Mus. Mag.,* Sydney, 12: 115-120.
———— 1957: *Rec. S. Aust. Mus.,* Adelaide, 13: 1-49 (14 figures).
———— 1957: *Trans. Roy. Soc. S. Aust.,* Adelaide, 80: 109-123 (10 figures).
———— 1957: *A.G.M.A. News Bulletin,* Brisbane, pp. 4-5.
———— 1959: *in* Keast, A., *editor. Biogeography and Ecology in Australia,* 36-51.
———— 1959: *Trans. Roy. Soc. S. Aust.,* Adelaide, 82: 119-120.
———— 1960: *Colorado Quarterly,* Boulder, Colorado, 8: 229-245.
———— 1961: *Rec. S. Aust. Mus.,* Adelaide, 14: 193-196.
———— 1963: *Annual Report, South Aust. Mus.*
———— 1964: *Aust. Journ. Sci.,* Sydney, 27 (1): 24.
———— 1965: *Rec. S. Aust. Mus.,* Adelaide, 15: 131-164 (23 figures).
———— 1966: *Aust. Natural History,* Sydney, 15 (6): 179-183.
———— 1967: *Colorado Quarterly,* Boulder, Colorado, 15: 339-353.
Tindale, N. B. and Maegraith, B. G., 1931: *Rec. S. Aust. Mus.,* Adelaide, 4: 275-289 (10 figures).
Tindale, N. B. and Mountford, C. P., 1936: *Rec. S. Aust. Mus.,* Adelaide, 5: 487-502 (8 figures).
Tindale, N. B. and Noone, H. V. V., 1941: *Trans. Roy. Soc. S. Aust.,* Adelaide, 65: 116-122 (10 figures).

OBITUARY NOTICE

Professor Thomas Draper Campbell, who died at his home at Tusmore, on December 8, 1967, at the age of 74, was a scientist with an international reputation. He was also a member of the Museum Board from 1932, Honorary Assistant Curator of Anthropoligy from 1923-1926, Honorary Curator of Anthropology from 1927-1939, and Honorary Associate in Physical Anthropology from 1940 until the time of his death.

T. D. Campbell was born at Millicent in the South-East of South Australia and educated at Prince Alfred College and the University of Adelaide. From 1916-1919 he served in the Dental Unit of the C.M.F. in South Australia. It was during this period that he completed the Dental Board Course which immediately preceded the establishment of the B.D.S. degree of the University of Adelaide in 1919. In 1921 he was one of the first to be awarded the new B.D.S. degree. He gained the D.D.Sc. degree by thesis in 1923 and the D.Sc. degree in 1939.

In 1919 Professor F. Wood-Jones joined the staff of the University of Adelaide as Professor of Anatomy. His enthusiasm stimulated the young Campbell and led to his intense interest in the Australian aboriginal. The thesis for his D.D.Sc. degree, published by the University of Adelaide in 1925, is titled *Dentition and Palate of the Australian Aboriginal.* The late Sir Arthur Keith, one of the world's outstanding anthropologists said, "His monograph in its method, scope, statement and exhaustiveness is a model which other workers will do well to follow. It supplies anatomists, anthropologists and dentists with data they stand much in need of and supplies them in a most acceptable form".

Soon after his graduation in 1921, Campbell entered the Dental Department of the Royal Adelaide Hospital as the first Dental House Surgeon, and in 1926 he was appointed to the position of Superintendent. In 1938, he was elected Dean of the Faculty of Dentistry, a position he held until his retirement. In 1949 he was appointed to the full-time University post of Director of Dental Studies and when the Chair of Dentistry was established in 1954 he became the first professor. On retirement in 1958 he was made Professor Emeritus.

During his professional career Prof. Campbell received high recognition for his work. In 1948 he was made F.D.S.R.C.S. (London); in 1950, F.D.S.R.C.S. (Edinburgh); in 1952 he was elected an Honorary Member of the Odontological Section of the Royal Society of Medicine, London, and in 1966 a Fellow of the Australian College of Dental Surgeons.

The foundation of the Anthropological Society of South Australia was due largely to the enthusiasm and effort of Prof. Campbell who, with Dr. R. H. Pulleine, sent out the initial circular letter calling a meeting of interested persons on June 28, 1926. At this meeting the Society, the first of its kind in Australia, was formed. Prof. Campbell contributed to its success for over 40 years, being a regular lecturer, member of the Council for many years and president in 1928, 1929, and 1944. He was a Life Member at the time of his death.

In December 1926 he was associated with the formation of the Board for Anthropological Research, University of Adelaide, and played a leading role in its various research activities. As organizer and leader of some 15 expeditions to Central Australia in the 1920's and 30's he was responsible for the collection of a vast amount of important data and material on many aspects of the traditional life of the aboriginals. Prof. Campbell was chairman of the Board at the time of his death.

Well known as an amateur film producer, Prof. Campbell first used a movie camera in May 1926, when he recorded scenes of aboriginal life during a field trip to Ooldea, in the far west of South Australia. These were the forerunners of many important South Australian films made during the 1930's and the more recent colour-sound series on aspects of aboriginal technology. These films, produced on a meagre budget, have been accepted widely and are used for educational purposes in many universities and colleges in the U.S.A. and Europe. Prof. Campbell made one film for the Institute of Aboriginal Studies and was an adviser for the production of two recent films on Central Australian ceremonies.

Prof. Campbell's interest in the aboriginals was not confined to his own specialized field of dentistry or to the production of movie records. Stone technology fascinated him and he spent countless hours searching for and making a very detailed study of aboriginal stone implements. Always proud of his birthplace in the Lower South-East many of his investigations were carried out in that region of South Australia. A comprehensive series of papers on the life of the aboriginals of this area, their stone implements and camp-sites provides an important basis for further studies. The culmination of this work came in 1963-65 when he led an Australian Institute of Aboriginal Studies sponsored investigation of archaeological sites. A rock shelter at Mount Burr was excavated and many stone implements and large quantities of faunal remains were found in the fourteen-foot deep trench. Charcoal from the lower levels has been radiocarbon dated to about 8,600 years. Important among the finds was evidence of the dingo in this region over 7,000 years ago.

Prof. Campbell held many official positions in connection with his lifelong interest in anthropology. Among these were: Fellow, Australian

Professor Thomas Draper Campbell, D.Sc., D.D.Sc., F.D.S.R.C.S. (Lond.), F.D.S.R.C.S. (Edin.), 1893-1967.

Research Council; Museum representative on the Aboriginal and Historic Relics Advisory Board; Foundation Member of the Australian Institute of Aboriginal Studies and a member of its Advisory Committee on Film Production; a Fellow of the Royal Society of South Australia from 1922, Councillor 1928-32, 1935, 1942-45, Vice-President 1932-34 and President 1934-35.

Prof. Campbell was well known as a keen debater and enjoyed nothing better than to engage in lively discussion on stone technology, artefact nomenclature, and other related subjects. Besides having numerous scientific papers and films to his credit perhaps his greatest contribution to anthropology was his intense desire to arouse interest in others. There are few South Australians working in anthropology or allied fields who have not been stimulated by his enthusiasm and encouragement.

Prof. Campbell belonged to a generation who had the benefit of extensive experience with nomadic aboriginals. Such opportunities are no longer available and today's researchers rely greatly on the recorded observations of Prof. Campbell and his contemporaries.

SELECTED BIBLIOGRAPHY

Campbell, T. D., 1924: An account of a hitherto unrecorded type of aboriginal stone object. Trans. R. Soc. S. Aust., Adelaide, 48: 74-78.

——— 1925: *Dentition and Palate of the Australian Aboriginal.* Adelaide.

——— 1925: A Dental anomaly in the skull of an Australian aboriginal. Trans. R. Soc. S. Aust., Adelaide, 49: 99-100.

——— 1925: Detailed notes on the aboriginal intaglios near Burra. Trans. R. Soc. S. Aust., Adelaide, 49: 123-127.

——— 1928: Dental Notes. Adelaide University Field Anthropology: Central Australia No. 5. Trans. R. Soc. S. Aust., Adelaide, 52: 28-30.

——— 1928: Recent progress in Ethnology in South Australia. Aust. Geogr., Sydney, 1 (1): 78.

——— 1934: Notes on the aborigines of the South-east of South Australia. Part 1. Trans. R. Soc. S. Aust., Adelaide, 58: 22-32.

——— 1936: Anthropology and the Royal Society (Centennial Address No. 2). Trans. R. Soc. S. Aust., Adelaide, 60: xix-xxiv.

——— 1937: Observations on the Teeth of Australian Aborigines. Hermannsburg, Central Australia. Aust. J. Dent., Melbourne, 41 (1): 1-6.

——— 1938: Observations on the Teeth of Australian Aborigines. Cockatoo Creek, Central Australia. Aust. J. Dent., Melbourne, 42 (2): 41-47.

——— 1938: Observations on the Teeth of Australian Aborigines. Mt. Liebig, Central Australia. Aust. J. Dent., Melbourne, 42 (3): 85-89.

——— 1938: Observations on the Teeth of Australian Aborigines. River Diamantina, South Australia. Aust. J. Dent., Melbourne, 42 (4): 121-124.

——— 1938: Notes on some teeth of an Australian aboriginal infant. Aust. J. Dent., Melbourne, 42 (5): 167-168.

——— 1939: Notes on the aborigines of the South-east of South Australia. Part 2. Trans. R. Soc. S. Aust., Adelaide, 63 (1): 27-35.

——— 1939: Food, food values and food habits of the Australian aborigines in relation to their dental conditions. Aust. J. Dent., Melbourne, 43: 1-15, 45-55, 73-87, 141-156, 177-198.

——— 1939: Dental conditions of aborigines compared with civilized groups. Mankind, Sydney, 2 (7): 228-229.

——— 1940: The drama and theatre arts of the aborigines. Mankind, Sydney, 2 (9): 329-330.

——— 1942: A suggested reconstruction of the missing anterior teeth of the Cohuna specimen. Rec. S. Aust. Mus., Adelaide, 7 (2): 235.

——— 1944: The dental condition of a skull from the Sikyatki site, Arizona. J. Wash. Acad. Sci., Washington, 34 (10): 321-322.

——— 1947: Notes on aboriginal camp sites on Yorke Peninsula, South Australia. Mankind, Sydney, 3 (11): 334-340.

——— 1947: Joint South Australia-Victoria expedition to the lower South-eastern region, South Australia. Mankind, Sydney, 3 (12): 380.

——— 1949: The Krefft tooth—is it a human molar? Rec. Aust. Mus., Sydney, 22 (2): 200-206.

——— 1960: The pirri—an interesting Australian aboriginal implement. Rec. S. Aust. Mus., Adelaide, 13 (4): 509-524.

——— 1962: Aborigines, dentition. Aust. Encyc., Sydney, 2nd ed., 1: 12-13.

Campbell, T. D. and Barrett, M. J., 1953: Dental observations on Australian aborigines: a changing environment and food pattern. Aust. J. Dent., Melbourne, 57: 1-6.

Campbell, T. D. and Cleland, J. B., 1946: The aborigines and their culture and the Half-caste problem. Rep. Aust. N.Z. Ass. Advmt. Sci., Sydney, 25th Meeting: 25-31.

Campbell, T. D., Cleland, J. B. and Hossfeld, P. S., 1946: Aborigines of the lower South-east of South Australia. Rec. S. Aust. Mus., Adelaide, 8 (3): 445-502.

Campbell, T. D. and Edwards, Robert, 1966: Stone Implements. *Aboriginal Man in South and Central Australia,* Part 1, Adelaide: 159-220.

Campbell, T. D. and Gray, J. H., 1936: Observations on the teeth of Australian aborigines. Aust. J. Dent., Melbourne, 40: 290-295.

Campbell, T. D., Gray, J. H. and Hackett, C. J., 1936: Physical Anthropology of the aborigines of Central Australia. Part 1. Anthropometry. Oceania, Sydney, 7 (1): 106-139.

——— 1936: Physical Anthropology of the aborigines of Central Australia. Part 2. Non-metrical characters of surface Anatomy. Oceania, Sydney, 7 (2): 246-261.

Campbell, T. D. and Hackett, C. J., 1927: Adelaide University Field Anthropology: Central Australia, No. 1. Descriptive and anthropometric observations. Trans. R. Soc. S. Aust., Adelaide, 51: 65-75.

Campbell, T. D. and Hossfeld, P. S., 1964: Aboriginal stone circles. Mankind, Sydney, 6 (4): 181-183.

——— 1966: Australian aboriginal stone arrangements in north-west South Australia. Trans. R. Soc. S. Aust., Adelaide, 90: 171-176.

Campbell, T. D. and Howchin, W., 1933: A rejoinder to some recent ethnological papers. Rec. S. Aust. Mus., Adelaide, 5 (1): 1-11.

Campbell, T. D. and Lewis, A. J., 1926: The aborigines of South Australia: anthropometric, descriptive and other observations recorded at Ooldea. Trans. R. Soc. S. Aust., Adelaide, 50: 183-191.

Campbell, T. D. and Moore, A. P. R., 1930: Adelaide University Field Anthropology: Koonibba, South Australia. Aust. J. Dent., Melbourne, 34: 123-127.

Campbell, T. D. and Mountford, C. P., 1939: Aboriginal arrangements of stones in Central Australia. Trans. R. Soc. S. Aust., Adelaide, 63 (1): 17-21.

Campbell, T. D. and Noone, H. V. V., 1943: South Australian microlithic stone implements. Rec. S. Aust. Mus., Adelaide, 7 (3): 281-307.

——— 1943: Some aboriginal camp sites in the Woakwine Range Region of the South-east of South Australia. Rec. S. Aust. Mus., Adelaide, 7 (4): 371-395.

Campbell, T. D. and Walsh, G. D., 1947: Notes on aboriginal camp sites on Yorke Peninsula, South Australia. Mankind, Sydney, 3 (11): 334-340.

——— 1952: Aboriginal implements from camp sites in the South of South Australia and Victoria. Mankind, Sydney, 4 (8): 339-342.

Ward, L. K., Campbell, T. D., Hale, H. M. and Tindale, N. B., 1936: Fossil man in the State of South Australia. Rep. Wash. geol. Cong., Washington, 16: 1271-1273.

Wood-Jones, F. and Campbell, T. D., 1924: Six hitherto undescribed skulls of Tasmanian natives. Rec. S. Aust. Mus., Adelaide, 2 (4): 459-469.

———— 1924: Anthropometric and descriptive observations on some South Australian aboriginals, with a summary of previously recorded anthropometric data. Trans. R. Soc. S. Aust., Adelaide, 48: 303-312.

———— 1925: A contribution to the study of Eoliths: some observations on the natural forces at work in the production of flaked stones on the Central Australian tablelands. Jl. R. anthrop. Inst., London, 55: 115-122.

MOVIE FILMS

Professor Campbell, in association with the Board for Anthropological Research, University of Adelaide, was responsible for the direction and production of many monochrome and colour/sound movie films on various aspects of traditional aboriginal life. The following is a selected bibliography of the most recent productions.

'So They Did Eat' (1953). Food and food habits, gathering and hunting food supplies, preparation and cooking. 900ft.

'The Boomerang' (1958). A record of aboriginal technology showing the making and various uses of the ordinary type of boomerang of Central Australia. 420ft.

'The Woomera' (1958). A record of aboriginal technology showing the stages of the making of the spearthrower and the many uses it serves. 560ft.

'Nabarula' (1958). A brief film story of the life of an aboriginal girl, from her babyhood in the bush to her young adult years and motherhood. 900ft.

'Palya' (1963). Prepared spinifex gum—the collection, cleaning, preparation and heat treatment of the grass resin; some of the uses of the gum. 420ft.

'Aboriginal Spears' (1963). Illustrating the manufacture and use of two main types of spears. 650ft.

'Aboriginal Hair String' (1963). A record of the manufacture and uses of aboriginal human hair string; showing the raw material, construction and use of the spindle-bobbin, teasing and spinning the string thread. 900ft.

'Aboriginal Axes' (1965). Old time aboriginal stone axe quarry, grinding an axe "blank", mounting a ground stone axehead. 500ft.

'Ngoora' (1965). An enactment of the movement of a small group of aboriginal people to a new camping site. Various activities on the journey and the preparation of the new camp are depicted. 1,830ft.

R. E.

PREHISTORIC ROCK ENGRAVINGS AT THOMAS RESERVOIR, CLELAND HILLS, WESTERN CENTRAL AUSTRALIA

By ROBERT EDWARDS, Curator of Anthropology,
South Australian Museum

Figs. 1-9

SUMMARY

This paper records prehistoric rock engravings at Thomas Reservoir in the remote Cleland Hills in western Central Australia. A brief account is given of the discovery of the site and the events leading to its detailed examination. The engraved designs and a small series of ochre paintings are described and illustrated, their significance is discussed and a comparison is made with other sites in Central and South Australia. A number of unique designs depicting human facial details is recorded and their origin considered. Camping places and associated stone implements are also noted.

INTRODUCTION

The early Australian explorers blazed trails across the continent leaving vast regions to be examined in detail by later investigators. Central Australia was one such region where large areas remained unexamined long after McDouall Stuart had opened the way to the north in 1862 and the Overland Telegraph Line had been constructed ten years later. It was not until 1889 that the Cleland Hills were discovered by Tietkens in the course of a detailed exploration of the Centre. His party set out from Bond Springs, north of Alice Springs, headed westward along the Macdonnell Ranges, passed Mount Sonder and Mount Solitary (Map, Fig. 1), and ultimately set up its twenty-seventh camp on May 13, 1889 at the south-eastern end of a low range, named by Tietkens the Cleland Hills after his friend, Dr. W. L. Cleland, father of the South Australian scientist Professor Sir John Cleland. By making its approach from the south the party missed the large natural rockhole located in one of the gullies on the north side of the range. The discovery of this permanent water, of great value to later explorers, is credited to Maurice and Murray who were the first to explore the north side of the Clelands. In the winter of 1902 Maurice organized and led an expedition from Fowlers Bay in South Australia across the centre of Australia to Wyndham on the north-west coast. The party, travelling by camel, camped south-east of the Cleland Hills on July 18. Maurice (1902a) records ". . . very heavy and continuous sandhills crossed today . . . blacks promised to show us a water tomorrow". They ". . . never came,

but we managed to find it ourselves and a tremendous rockhole it was . . .” (1902b). The party had worked its way around the hills and discovered a creek outlet where several Aboriginals were seen to run off; the party followed their tracks up the creek and discovered the rockhole. “We were surrounded by blacks, but they would not come anywhere near us, and so we could not get in touch with them at all”, Maurice remarked in a later account of the expedition (Maurice, 1902b).

The name “Thomas Reservoir” was given to the rockhole in honour of Sir Robert Kyffin Thomas, a grandson of the founder of the South Australian Press, and President in 1902 of the South Australian Branch of the Royal Geographical Society of Australasia which assisted the project.

Explorer R. T. Maurice and his surveyor companion W. R. Murray also made the first discovery of Aboriginal art at Thomas Reservoir. “. . . we came across some native drawings and a curious native hieroglyphic on a tree” is the brief and inadequate description given by Maurice (1902b). Murray examined the hills to the south of the rockhole and found

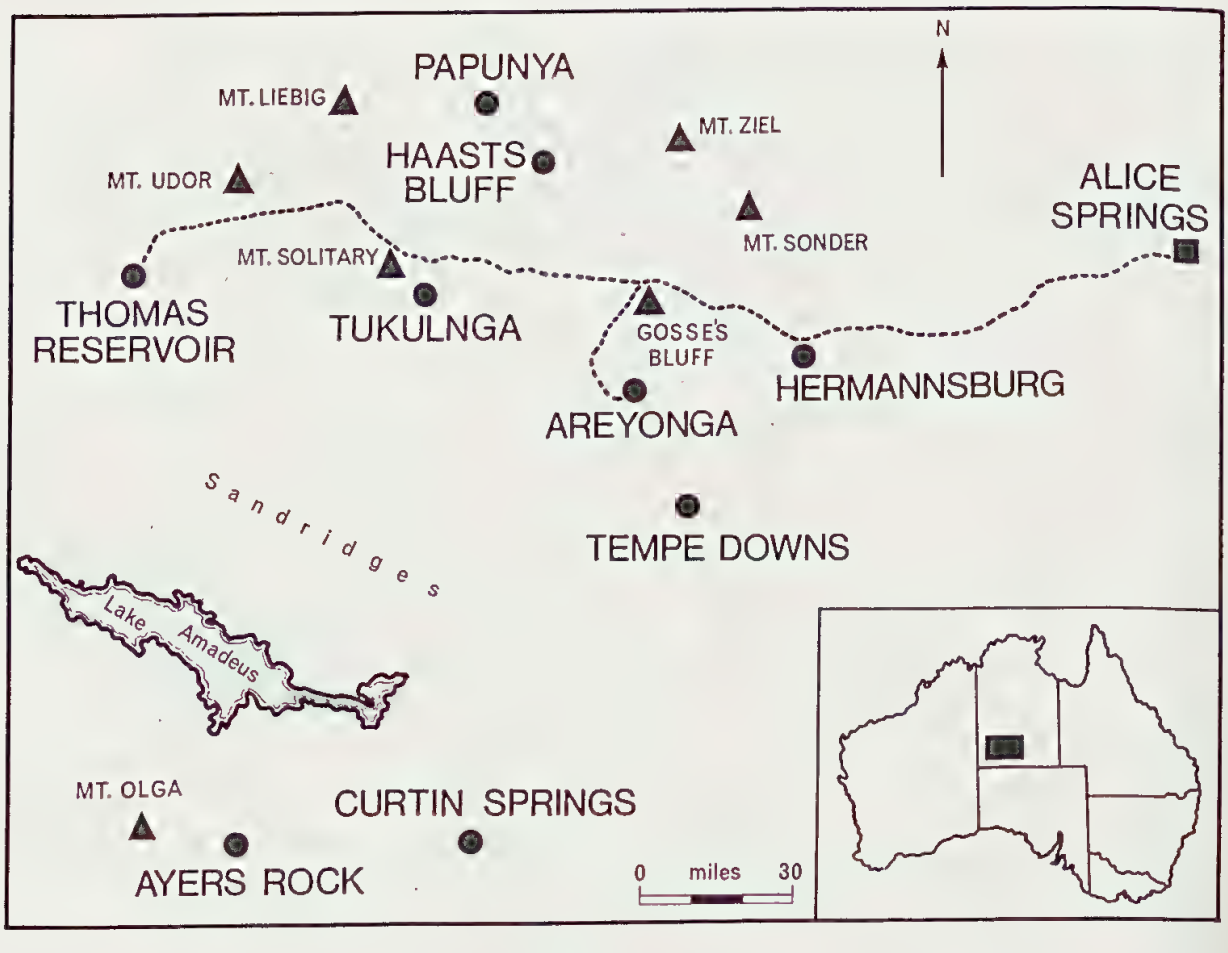


FIG. 1.
Map showing the location of the Thomas Reservoir site in Western Central Australia.

other paintings, remarking, "The soft sandstone readily forms into caves which the natives use for camping places in wet or windy weather. There are native drawings in many of them, but they are very poor and indistinct" (Murray, 1902). Examination of these rock shelters in 1967 showed that there is now no trace of the paintings nor any accumulated occupation deposit.

While at Thomas Reservoir, the explorers marked two gum trees, one near the waterhole with $\frac{R\,T\,M}{1902}$ and the other a short distance away with a large M. Although partly covered by regrowth the latter blaze still survives.

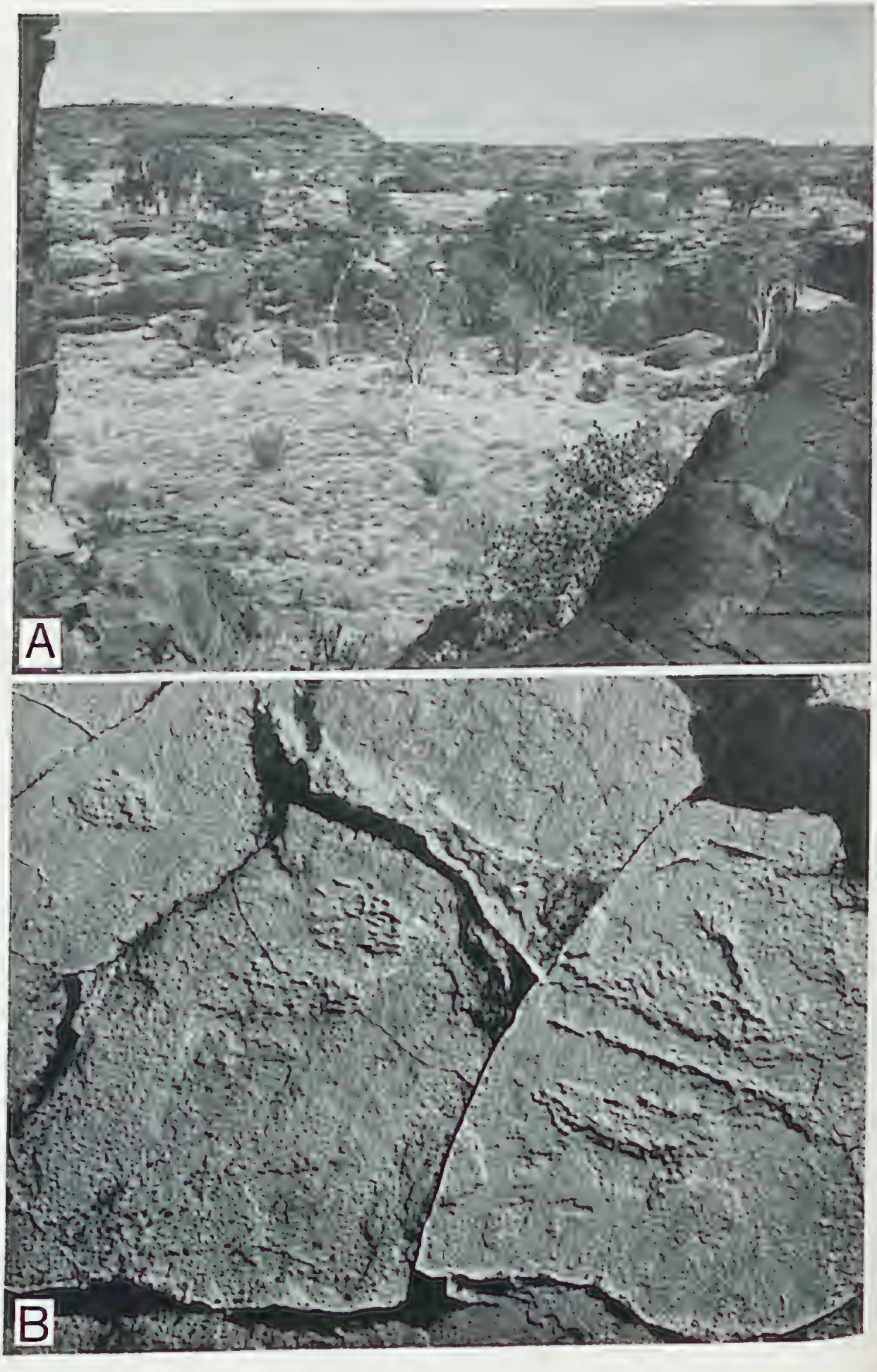
Many years later H. H. Finlayson called at the rockhole during his Central Australian journeys, and initials on a cliff-face testify to other visitors to this remote oasis. Prospectors, survey teams and parties in search of Lasseter's elusive gold finds have made Thomas Reservoir a stopping place. No-one has provided an account of the rock engravings and quite probably they were unnoticed by these visitors.

For 60 years, until 1961, when explorer, prospector and author, Michael Terry, of Sydney, visited Thomas Reservoir, the references in the unpublished reports of Maurice and Murray were the only records of what has proved to be one of the most important prehistoric art sites in Australia. This was Terry's second visit to the Cleland Hills. He called there first on camels in September-October 1932 while prospecting (Terry, 1932), but on that occasion did not notice any of the art or other indications of past Aboriginal occupation. This is not surprising, for rock engravings can easily be overlooked. They are frequently difficult to see unless the sun is at an appropriate angle to provide strong cross lighting which emphasizes the relief.

In his later published accounts Terry compared the engravings with Egyptian and Assyrian art and claimed an association, but the photographs he published and the evidence he provided were unconvincing, and so his plans for a full and immediate investigation were largely ignored. Realizing his own limited knowledge of prehistoric art, Terry sought a sponsor for an expedition, including an anthropologist familiar with rock engravings, to make a detailed record of the site and report on its significance. Six years later, between September 7-19, 1967, Terry guided a joint Australian Institute of Aboriginal Studies and South Australian Museum expedition to the Cleland Hills. This paper records the results of that investigation.

DESCRIPTION

The Cleland Hills are just over 200 miles due west of Alice Springs (Map, Fig. 1). Fortunately they are situated on the Central Australian Aboriginal Reserve and so are afforded a measure of protection from


A
B

vandalism, as a permit is necessary to enter the area. Isolated amongst vast loose red sand-dunes the Clelands were more easily accessible to the explorers' camels than they are to four-wheel drive vehicles.

The expedition approached from the northern side which presents an escarpment. Access to the site is by way of a rocky gorge with precipitous sides. The bed of the gorge had been scoured by heavy rains of two good seasons following the prolonged Central Australian drought of the early 1960's. Once through the gorge the country opens out to an undulating sandy area between hills and associated gullies. The rockhole is hidden by undergrowth at the end of an inner gully (Fig. 2A). Progress is impeded by a watercourse which takes the overflow and has cut a channel exposing a continuous bed of large boulders. There is a scatter of Ghost Gum trees (*Eucalyptus papuana*), and native tobacco (*Nicotiana ingulba*) flourishes throughout the area.

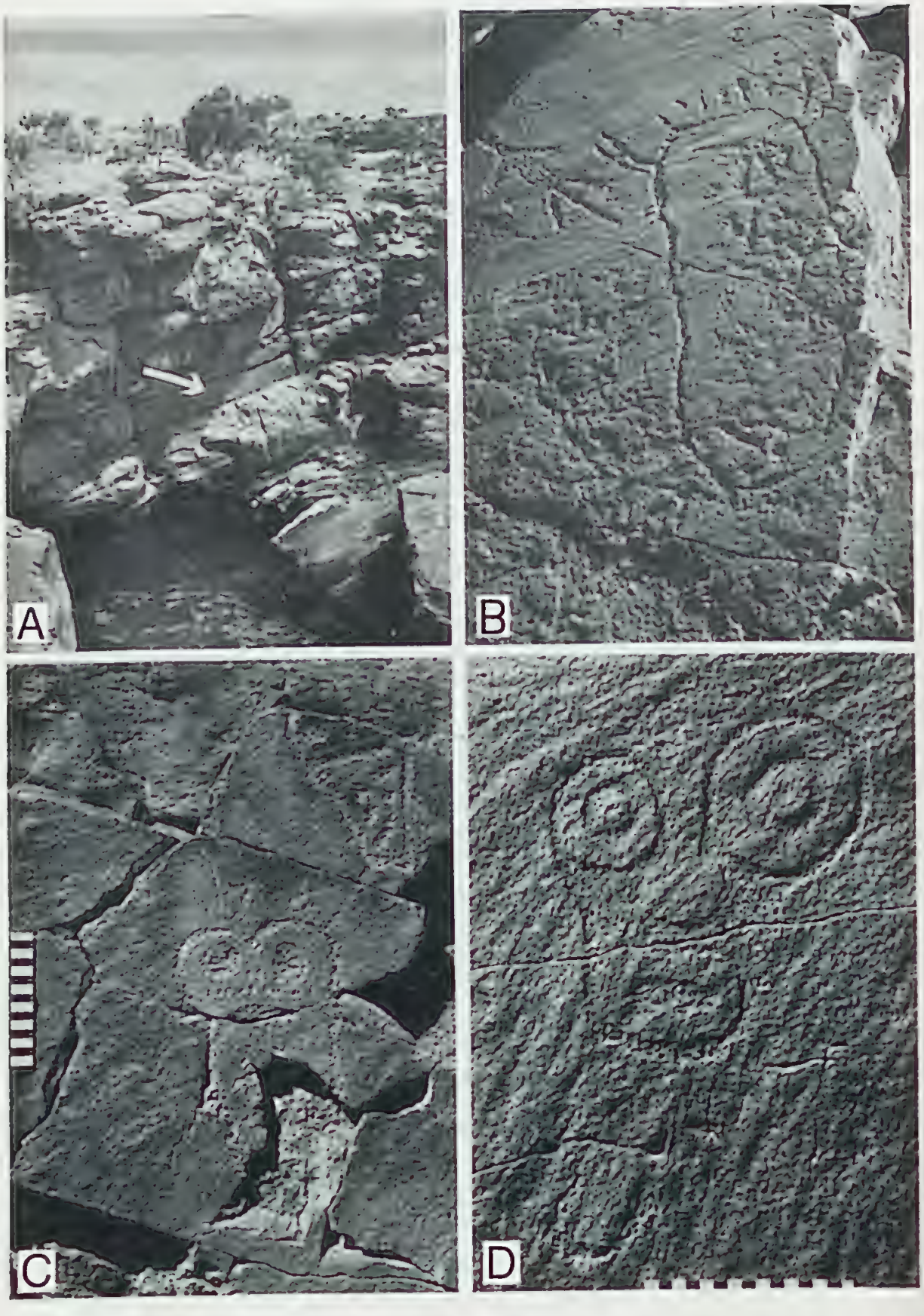
The rockhole (Lat. 23 deg. 42 min. S: Long. 130 deg. 49 min. E) is the main topographical feature in this part of the hills. It is 85ft. in length, 21ft. deep, and is very impressive, with cliffs rising sheer from the water's edge to a height of about 45ft. (Fig. 3A). It has a calculated capacity of half a million gallons. There is no associated spring, but the surrounding hills provide an efficient catchment during periodic thunderstorms. The cliffs and dense trees shade the rockhole, keeping evaporation to a minimum. Such a water supply in the midst of an arid desert region would have provided a strong inducement to the Aboriginals of recent and no doubt of long past times to frequent the site.

The hills of this region are composed mainly of fine, evenly-grained sandstone although there is some conglomerate. Because of iron oxide in the matrix the rock surface is a slightly mottled buff and brown. Many rocks have separated along joints and large blocks have been dislodged and have fallen from the cliffs down the hillside; pavements are broken, flat slabs have slipped out of place along the bedding planes and boulders are strewn on the hills and floor of the gully. All have been weathered extensively. It would not be surprising if such unusual features, adjacent to a permanent water supply, had considerable mythological significance for the Aboriginals, as the formation of physical features is usually attributed by them to totemic ancestors of their Dreamtime. It is unfortunate that efforts to obtain reliable informants who know the myths associated with the site have not so far been successful.

FIG. 2.

A. The large permanent rockhole is hidden by dense undergrowth (centre) at the end of an inner gully.

B. These simple engravings represent a kangaroo sitting with tail and fore-paws on the ground.


A
B
C
D

Besides the explorers' observations of Aboriginals at the site, there is tangible evidence of comparatively recent occupation in the form of ochre paintings, camp-sites and scars on the gum trees where bark dishes have been removed. The numerous engravings on the surface of the rocks surrounding the rockhole are survivals of the activities of man at a much earlier period.

ROCK ENGRAVINGS

On arrival at the Cleland Hills, after a prolonged and difficult journey across the seemingly endless red sand-dunes, Terry guided the party to the rockhole, where he pointed out the large engraved block of stone which had led to his extravagant claims for the site (Fig. 4A). The engravings on this stone are mainly abstract linear designs and small dots which do not appear to conform to any general pattern or depict any identifiable animal or object. The most interesting design is a heart-shaped face (Fig. 4B) of owl-like appearance and quite different from any other recorded Aboriginal motif. Weathering of the front of the rock, including the engravings, is more advanced than on the other surfaces, indicating that it had been engraved before being lodged in its present position.

Nearby was another of the engravings Terry figured in his account. The published photograph had been heavily retouched and showed little of the fine detail of this unusual and well-preserved engraving (Fig. 5A). It is on a fallen rock quite close to the other heart-shaped face. Two small horn-like protrusions extend from the top of the head and the mouth is more definite than on the other example. The eyes of both engravings are similar, being formed by two concentric circles around a central pit.

There is a third engraving of the same type but of a different style located in an inaccessible position high on the cliff overlooking the water. This engraving could have been made only when a rock ledge, since broken away, provided access. These three unusual engravings showing facial features left no doubt about the importance of Terry's find. Other engravings on the nearby cliffs were not so obvious and a close search was necessary to locate them.

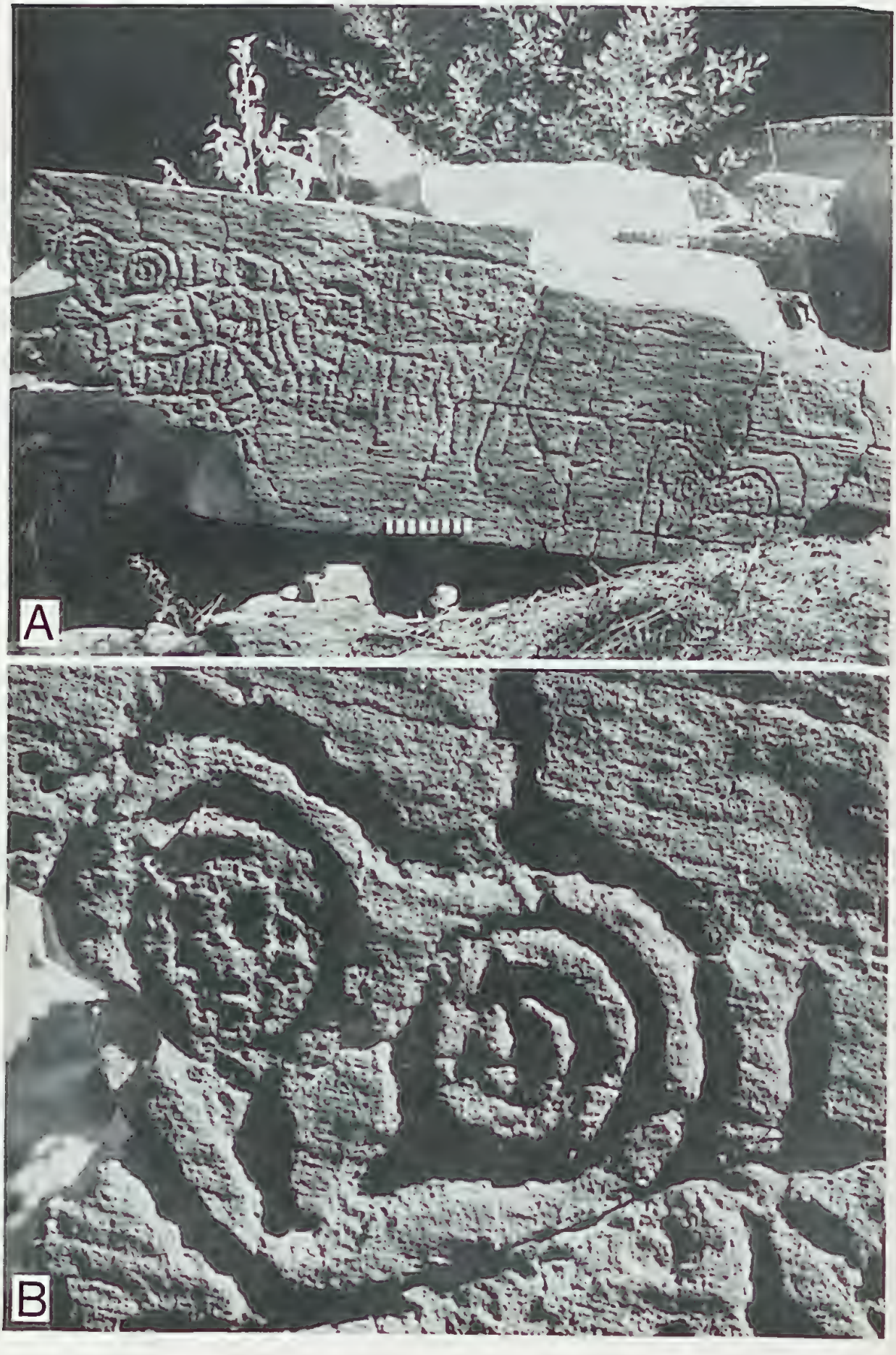
FIG. 3

A. Cliffs tower above the large waterhole. The arrow indicates the position of the red ochre paintings.

B. Simple engravings including a fully pecked lizard in plan. The engravings have re-weathered to match the natural colour of the rock surface.

C. Two unusual designs which may be a simple form of the heart-shaped face designs. Scale in centimetres.

D. A unique engraving with individualistic facial details suggesting expression. Scale in centimetres.


A
B

Using the rockhole as a central point a detailed examination was carried out in ever-widening circles, and an area of about one square mile was covered before the full extent of the site could be determined. Descriptions of the various rock-faces were recorded, engravings listed, photographs taken and latex impressions made.

The greatest concentration of engravings is on the cliffs and broken hills forming a rough amphitheatre around the rockhole. One occurrence of particular interest is on two rocks on top of the cliff immediately above the rockhole. Most of the designs are abstract (Fig. 6A-B) but there are some kangaroo tracks. Two designs which may be related to the heart-shaped faces were found on one badly fractured surface (Fig. 3C). They have the distinctive heart-shape, and engraved circular areas giving the impression of eyes. Other unusual combinations of circles and linear designs were found on a nearby cliff. Identifiable designs in this area include emu, kangaroo and bird tracks, a small human figure, a star-like motif, circles and a number of linear engravings. Circles are sometimes linked to form interesting abstract designs. When arranged in pairs they give the impression of being an early stage in the development of the unusual face designs which are a feature of the site. The extreme weathering of the rocks made classification of many designs very difficult, and there are large vertical areas with indications of many elaborate engravings which are too weathered to decipher. In one place the branches of several large trees have been rubbing against the cliffs and have combined with natural fretting to obliterate the outline of many engravings.

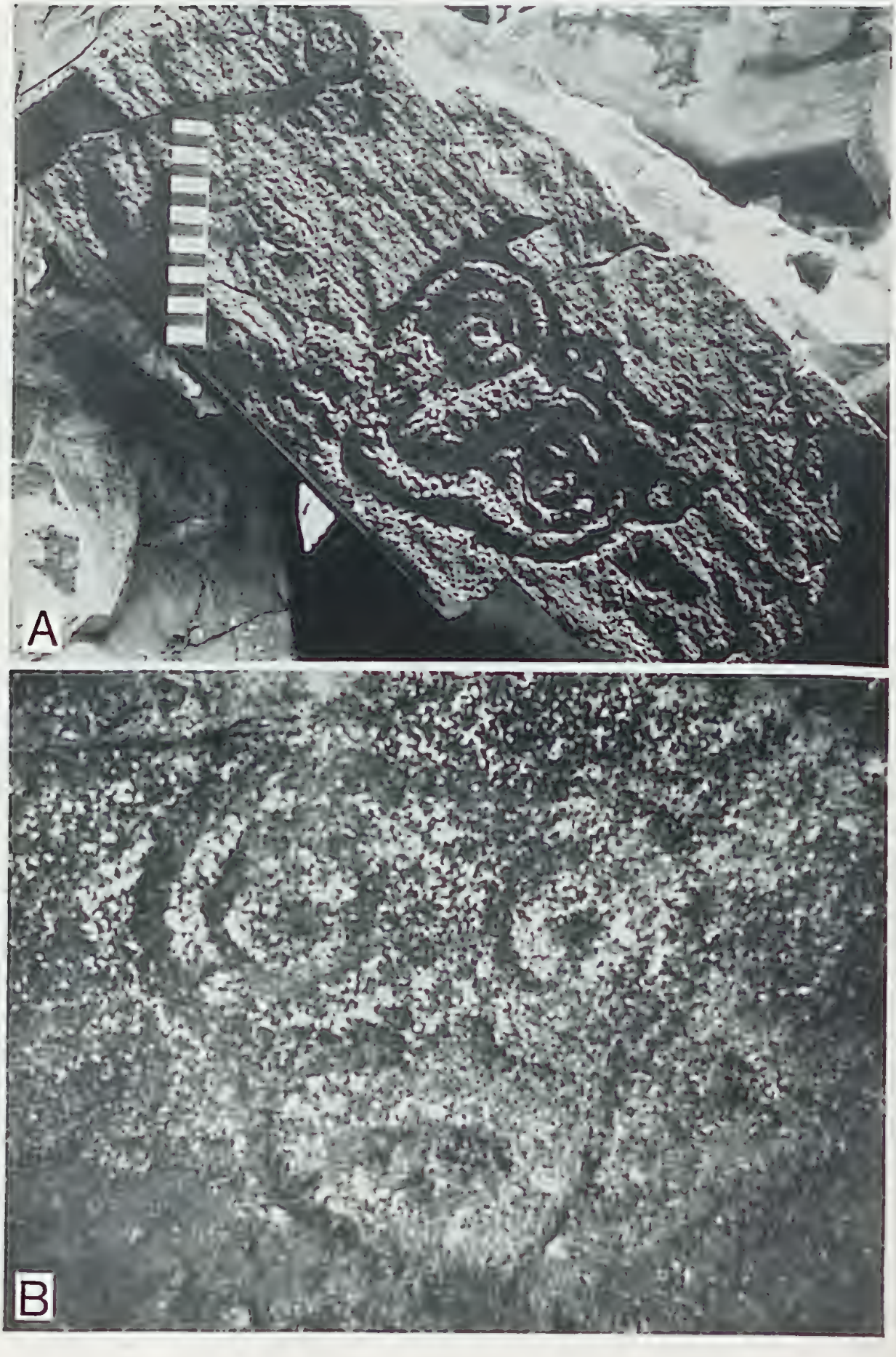
As the search extended beyond the rockhole area new and interesting finds were made on the adjoining hills. On one vertical rock-face there are two engraved faces complete with eyes, nose and mouth but lacking full facial outlines. One of these remarkable engravings (Fig. 7D) has no forehead although the line of the chin has been shown. The eyes are formed by simple circles with central pits to represent the eye-balls. There is an economy of line as the circles forming the eyes also provide the outline of the face. The nose and mouth are quite distinctive and there is clearly a cheerful expression. Two small triangles have been made near the base of the face and two long lines extend below. These may have been intended as a stylized representation of a body (Fig. 7C).

The second face is even more remarkable in that its features form a distinct expression of sadness (Fig. 3D). This face also lacks a forehead

FIG. 4

A. A large block of stone dislodged from the cliff where it was originally engraved. Scale in centimetres.

B. This heart-shaped, stylized face, engraved deeply into the soft sandstone, was one of the first engravings to be found at Thomas Reservoir.


A
B

but nose and mouth are distinctive and have been given quite individual treatment. The eyes are formed by two concentric circles and a central pit, a style identical to that of the heart-shaped faces near the rockhole. In this example, however, the outside circle forms part of the facial outline and indeed continues on to depict the nose. There is a small crescent-shaped design below the face. On an adjacent boulder there is a smaller face, round in shape and only 4in. in width but with the distinction of having a complete outline.

Another of these intriguing engravings was found on a vertical rock surface a short distance away. In this instance the face is attached to a peculiar body, separate from the arms and legs which are arranged in such a way as to suggest movement (Fig. 7B). The face has a complete outline and eyes are formed inside this by two circles with central pits. Nose and mouth are again clearly depicted but in an individualistic style. The facial expression, which is unmistakably one of happiness, demonstrates the skill of the prehistoric craftsman in achieving such detail by a comparatively crude technique. Indeed, the portrayal of feeling in many of the Cleland Hills face designs is a unique feature in Australian Aboriginal art which, in rock engravings, is usually very simple and often abstract.

A stylized human figure is engraved on the same rock surface as the unusual, elaborate example (Fig. 7A). The two display a striking similarity in pose but the styles are quite different. Weathering of the surface is even indicating that the two diverse forms may be contemporary or at least closely associated.

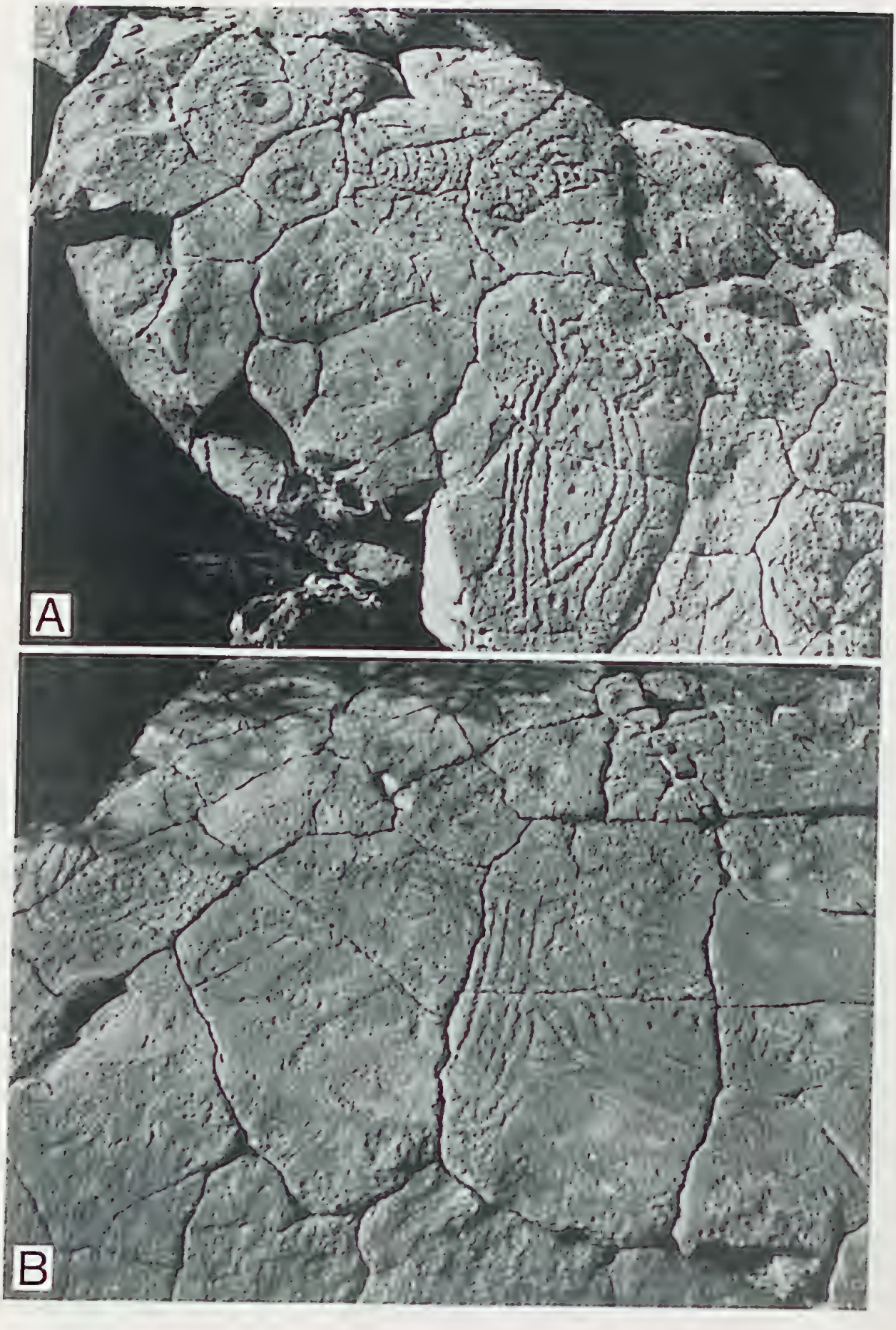
In this same area, as on the cliffs near the waterhole, there are other designs of a type common to most engraving sites in the centre of Australia. These designs include the usual animal tracks, one depicting a kangaroo sitting with fore-paws and tail on the ground (Fig. 2B), circles, a crescent in outline, and two plan aspects of lizards (Fig. 3B), one of them with individual toes depicted.

As the examination extended beyond the tops of the cliffs and adjoining hills the engravings diminished, finally petering out about 400 yards from the rockhole. Here the country tends to flatten out although there are many suitable rock surfaces which do not appear to have been engraved. Another line of broken and weathered hills extends further on but a search of these failed to produce any evidence of engravings, thus indicating that the site is limited to a relatively small area around the waterhole. This association

FIG. 5

A. A remarkable engraved face on a fallen block of stone. Scale in centimetres.

B. Weathering has almost obliterated this face from the surface of the rock. It is only visible when the sun provides strong cross lighting to emphasize the relief.


A
B

of rock engravings and permanent water supplies is a constant feature at most recorded Australian sites (Edwards, 1965). The engravings on the fringe of the site are mainly animal tracks occurring singly or in small groups. Several of the track designs are incomplete and seem to show only the initial work for engravings. Apparently the outline was first marked on the surface by light pecking and then the central portion was chipped out by the repeated action of a piece of sharp stone, presumably struck with another, as with a hammer and chisel. By this means sufficient control could be maintained to form the more precise designs. This pecking technique has had a wide application throughout Australia. The only exception at Thomas Reservoir was found in a series of shelters weathered into the soft rocks along the escarpment of the hills which form the entrance to the reservoir gully (Fig. 8A). In one of these shelters there are two large boulders cut with deep abraded grooves (Fig. 8B). These markings also have a wide distribution and in some regions are believed to be associated with rain increase rites (Arndt, 1962).

There are a few engravings on the rocks in the bed of the creek which takes the overflow from the rockhole. Most of these have been worn by the erosive effects of water-borne sand. Some are extremely faint. It may well be that others have been completely obliterated.

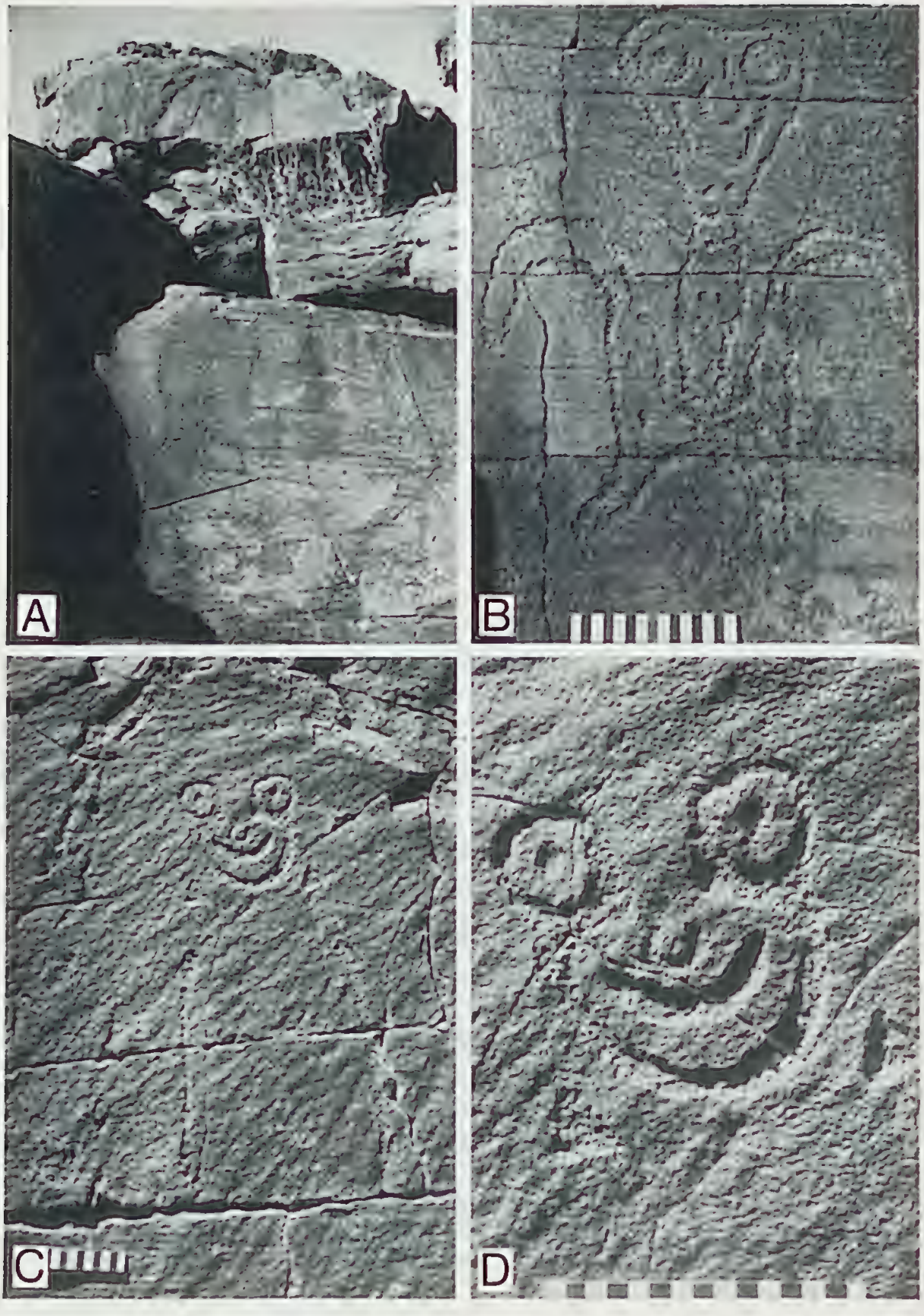
The advanced weathering of the rocks has had a devastating effect on the engravings and made compilation of a complete inventory of individual designs impossible. Each rock surface had to be examined at several different times of the day to take advantage of the effects of cross lighting and enable identification of some of the faint designs. Even after several days of intensive study yet another engraved face was noticed on the surface of a large outcrop a short time before departure from the site. This engraving, which again exhibited individualistic treatment of detail, has been almost completely erased by weathering (Fig. 5B).

In many instances throughout the site broken pavements occur with only portions of designs intact. The missing pieces have completely disappeared, indicating advanced movement and disintegration of the rocks. Identification of designs and estimates of the frequency of their occurrence can only be made with the qualification that the sample available is but a small proportion of a once elaborate and extensive site.

FIG. 6

A. Unusual abstract designs engraved on a large rock at the top of the cliff. The surface is breaking up and many of the designs are in danger of being dislodged.

B. Centuries of weathering have almost removed the simple markings from this surface.


A
B
C
D

Identifiable designs at the Cleland Hills number 387. The following table shows the relative frequencies of the various designs, and the results from similar analyses carried out at Tukulnga rockhole, 50 miles to the east in the Gardiners Range (Map, Fig. 1), and at four sites about 850 miles away in South Australia.

Site	Units	Percentages			
		Tracks	Circles	Total	Other Designs
Florina	985	48.3	39.9	88.2	11.8
Panaramitee.....	1,003	57.6	26.7	84.3	15.7
Tiverton	2,736	72.0	16.7	88.7	11.3
Winninninnie	3,236	71.3	16.7	88.0	12.0
Tukulnga	3,186	71.3	24.4	95.7	4.3
Cleland Hills	387	50.0	33.0	83.0	17.0

The figures show that 50% of the engravings at Thomas Reservoir are animal tracks. The largest proportion are emu, which occur more than twice as often as all other tracks. The total proportion is similar to that at Florina in South Australia. Circles account for another 33%, and all other designs 17%. Although the percentage of tracks and circles is lower than at any of the sites considered it is still high and generally comparable with the other sites. The unique face designs are only about 4% of the total. This is consistent with other recorded sites which usually have a small percentage of highly unusual designs, in most instances abstracts.

This analysis will be extended as percentages become available for other sites.

ROCK PAINTINGS

On the cliff-face immediately above the waterhole there is a series of red ochre paintings consisting of 55 large emu tracks, 12 small ochred circles

FIG. 7

A. A unique human figure on a vertical rock-face. A nearby stylized figure (right) has a similar body attitude.

B. The prehistoric rock engravers achieved a happy expression on the face of this strange human figure. Scale in centimetres.

C. Two engraved lines below this face may be a simple representation of a body. Scale in centimetres.

D. With a minimum of engraving and by the use of a simple pecking technique this remarkable facial expression was permanently recorded on stone many centuries ago. Scale in centimetres.

A
B

and some oblong marks. Five of the emu tracks are very large. Access to the area where the designs have been painted is provided by a narrow ledge (Fig. 3A). The paintings are very faded and it is difficult to decide whether the surviving composition is complete. As the cliffs shelter the paintings, and the surface is hard and well preserved, the rate of deterioration has probably been comparatively slow. A photograph of the rockhole taken by Maurice in 1902 shows a similar group of paintings in the same position but in slightly better condition.

CAMP-SITES

It was customary for the main living camps of the Aboriginals to be located at a discreet distance from ceremonial sites, as most of the rituals were prohibited to all but initiated males and any infringement brought immediate and drastic punishment.

A close search was made for camp-sites and associated artefacts. Three main camping areas were found: one at the entrance to the gorge on the north side of the range, a second on the open flat between the entrance gorge and the rockhole, and a third on sandhills about half a mile beyond the site.

There were few stone implements considering the permanence of the waterhole and evidence of considerable human activity. A broad scatter of stone flakes was found on the three camp-sites. A few of irregular shape have secondary trimming along the margins. One of the only implement types of pre-determined shape was the adze stone, of which 35 worn examples were collected. Large grinding stones were a feature of all camp-sites. Constant grinding of seeds to make flour for "cakes" had produced a single depression on most; others were worn on both sides while a few had three hollows. Small top grinders were also found. The prevalence of these large and heavy artefacts on all camp-sites is an indication that they were left there permanently and used during periodic visits.

The only implement found which is likely to have any great antiquity was a large trimmed flake, of a shape commonly known as a "horsehoof". It has a base 3 inches in diameter and is 2 inches high. This implement was found partly buried in the soil between rock outcrops at the top of the hill a short distance from the unusual engraved human figure. It is made from a large flake, and evidence of the percussion point and conchoidal fracture

FIG. 8

A. Two large boulders with grooves abraded deeply into their surfaces lie in one of the rock shelters formed along an escarpment in the Cleland Hills.

B. These abraded grooves are more concentrated and deeper than those found at other recorded sites.

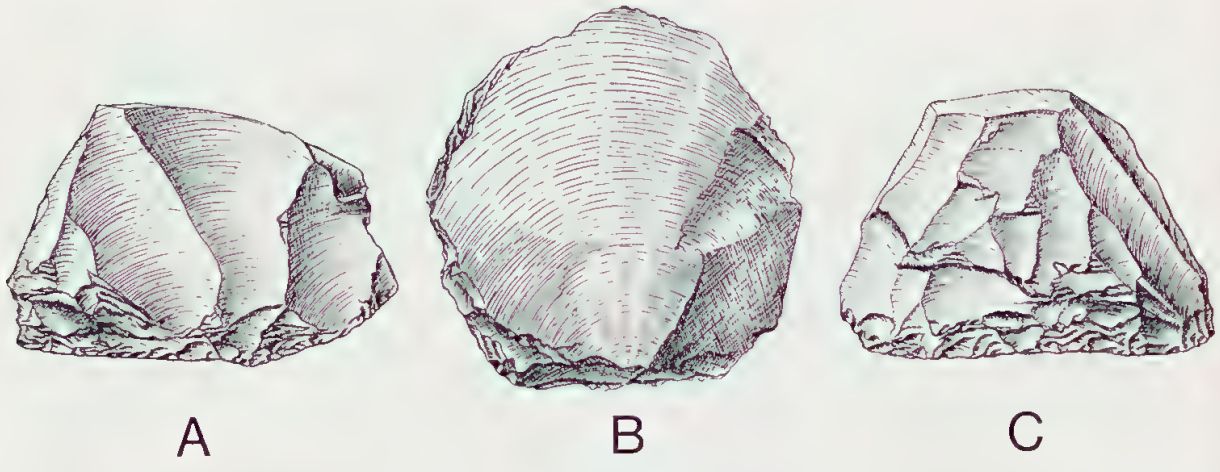


FIG. 9

Side, base and front views of the trimmed core implement found near the engravings at Thomas Reservoir.

can be seen on its base (Fig. 9B). Step-trimming has been developed along the distal margin (Fig. 9A) and there are indications of re-sharpening. The working edge is sharp and still capable of useful work.

Other evidence of Aboriginal activity was provided by the scars on gum trees near the rockhole and in the vicinity of the camp-sites. These have been caused by the removal of pieces of bark for use as carrying dishes. No sooner is the bark removed than the tree begins to repair the damage. New growth gradually heals the scar, ultimately leaving only a callus on the bark. All the scars at Thomas Reservoir are completely healed, suggesting that Aboriginal occupation of the site ceased many years ago. The rate of regrowth has not been established but a control tree was cut at Yuendumu in 1965 and records are being kept of the annual healing rate. It is interesting to note that the tree blazed with a large "M" by Maurice in 1902 has still not completely healed.

DISCUSSION

The location of sacred painting sites near water supplies with camping places at a convenient distance is characteristic of the known traditional nomadic way of life of the Central Australian Aboriginal. To him painted tracks usually represented the totemic ancestors of the Dreamtime who travelled across the landscape and formed its features. As the emu is the subject of many myths and rituals, the red ochre paintings of emu tracks at Thomas Reservoir no doubt belong to one of these ceremonies. The presence of a large number of engraved emu tracks at this site may indicate that the emu ceremony dates from a period when rock engraving was a living art.

An almost identical situation has been recorded at Tukulnga rockhole (Edwards, 1966) where a ceremonial site is associated with large rock cisterns and camping places. Here the engravings are said by the Aboriginals to belong to the Dreamtime while ochre paintings are part of present-day emu ritual. As the Cleland Hills are on the boundary of the Pintubi and Kukatja tribes (Tindale, 1940), and as there is only about 50 miles between the two sites, they may well be concerned with the same emu myth.

The significant feature of the Cleland Hills site is the 16 engraved faces. Not only are these unique in Australian rock art but they are more advanced than the pecked engravings recorded in Europe (Kühn, 1956), North America (Heizer and Baumhoff, 1962), Southern Africa (Slack, 1962) and the other continents.

The origin of these designs is a mystery. They could have been brought to Australia by prehistoric man, developed at a series of sites within the country, or be a unique occurrence at Thomas Reservoir. Although attempts to find a source outside Australia have not been convincingly successful the possibility of diffusion from Melanesia cannot be discounted as there is a number of rock engravings at Likding on New Hanover, Territory of Papua-New Guinea, which depict facial details (Bühler 1948-1949, Abb. 11, a to q). Some of these are heart-shaped, have been made by the pecking technique, and are very weathered—all factors consistent with some of the face engravings at Thomas Reservoir.

A study of Central Australian sites has not produced any parallels. The art of this region is highly stylized, the main symbols being simple and concentric circles, spirals, U-figures, straight and curved lines, tracks and small stylized human figures. In cave paintings these comparatively few basic units are arranged in various patterns and executed in different colours to form a great variety of extremely impressive and pleasing compositions.

Mountford (1960) records rock engravings at Ewaninga a few miles south of Alice Springs, where tracks, circles and abstract designs are concentrated on rock outcrops near a small claypan. He also refers to engravings at ten other sites in Central Australia but without any description. During the survey of art sites in the Northern Territory sponsored by the Australian Institute of Aboriginal Studies in 1965-67 the author carried out detailed studies at N'Dahla and Roma Gorges, Areyonga and Tukulnga Rockhole (Edwards, 1966). Examination of all these sites indicates that the great majority of engravings in Central Australia falls within the normal range of designs. There are a few exceptions but none bears any similarity to the new finds at Thomas Reservoir.

No link has been found in the regions to the north where detailed study of engraving sites is also just beginning. Sites have been examined in the Katherine district and at Willeroo, Delamere, Mainoru, Innesvale

and O.T. Stations but the engravings at these sites are mainly simple. Tracks are common, as are abraded grooves. The most elaborate designs were found at a new site on Delamere Station where large intaglios of animals in silhouette, similar to those recorded at Mootwingee in western New South Wales (McCarthy and Macintosh, 1962, pl. 23, 2), occur on large broken pavements. There are vast regions to the north yet to be examined and an extension of the present survey will provide additional comparative material of great value in solving the mystery surrounding the origin and antiquity of Australian rock engravings.

At Port Hedland, on the Western Australian coast, some 800 miles from the Cleland Hills, there are an estimated 15,000 engravings forming one of the largest concentrations on the continent (McCarthy, 1962). There is a great diversity of style from simple tracks and circles to naturalistic portrayals of animals and stylized human figures, a number reaching 12 feet in height. Although some of the human outlines have eyes, nose and mouth, they are shown very simply and are far removed from the comparatively sophisticated art form of the face engravings. The possibility of diffusion from the west therefore seems unlikely.

If the face designs were a local development by an individual craftsman or group, there is not yet evidence of diffusion in the adjacent regions. Perhaps the reason for this lies in the rigid adherence to traditional forms. Strehlow (1964) records that ". . . all breaches of the rules regulating the transmission of the sacred traditions : . . . and the artistic use of the decorative patterns and combinations of totemic motifs, were punishable by death in Central Australia". Such control would have inhibited the diffusion of new styles. As the development of such customs and the links between paintings and engravings are unknown it is difficult to establish whether such prohibitions had any effect on rock engraving distribution.

The fact that the face designs are all different suggests they did not arise by the simple repetition of accidentally developed elements. The style always seems deliberate. Each facial detail is placed with precision and assurance. This is surprising in view of the Central Australians' persistent use of predetermined patterns in their art. Each element usually had a fixed position and meaning. The individual treatment of the face designs may mean that the rock engravers were intending to portray specific expressions, emotion or at least variations in their designs. However their intention must remain a matter of speculation. It may be that the freer style of the faces is a relic of an earlier period before ceremonial art became rigidly formalized.

The antiquity of rock engravings has been a matter of considerable speculation. Suggestions of great age have been supported largely by

circumstantial evidence such as the general deterioration of engraved outcrops, the patination of engraved rock surfaces, and association with ancient stone industries.

Surface weathering has been used as a criterion for age determination of rock engravings in Australia and overseas. For instance variations in re-weathering or patination shading of the engraved portions of rocks in the arid Negev region of Israel supplied Anati (1963) with information on the relative dates of various styles found on the same or adjacent surfaces. His work indicates that in this particular region it took a minimum of 2,500 years for an engraving to reach the natural colour of the rock. The surfaces at the Cleland Hills are weathered to a constant depth of only a fraction of a millimetre. All the engravings would have originally penetrated this dark surface layer to reveal the white rock beneath. Subsequent re-weathering has restored the engraved portions to the natural surface colour. Thin sections have been prepared, and the surface and core of rock samples are being analysed, to determine the nature of the weathering process, its cause, and if possible its rate of development. These samples have been taken from sites in southern, central and northern Australia so that the effects of different climatic conditions can be taken into account.

There is no apparent variation between the surface colouring of the simple and advanced designs at Thomas Reservoir. Had the face designs been made at a later period they would exhibit less patination indicated by a lighter shade of colour. Even the variation in the condition of the various designs is consistent as there are both well preserved and badly weathered tracks, while some face engravings in a vertical position are sound and others are almost obliterated.

The first phase of rock engraving in Australia is believed to be represented by abraded grooves (McCarthy, 1964). Confirmation of considerable age for these simple marks came first when they were found on the back wall of the Devon Downs rock shelter at a depth of between 10 and 13 feet (Hale and Tindale, 1930). Datable engravings were first discovered in an excavation at Ingaladdi on Willeroo Station, nearly 100 miles south-west of Katherine in the Northern Territory. The work, carried out in July 1966 under the leadership of Mr. D. J. Mulvaney, Senior Fellow in Prehistory at the Australian National University, produced several fragments of rock with abraded grooves and also kangaroo and emu tracks. These engravings were found between a level with an approximate depth of 3 feet 7 inches to 3 feet 10 inches and dated (A.N.U. 58) at 4920 ± 100 (2970 B.C.) and a lower level at approximately 5 feet 7 inches to 5 feet 10 inches and dated (A.N.U. 60) at 6,800 ± 270 (4850 B.C.). The fragments are badly weathered and most of the designs are incomplete, suggesting that they may have originally been pecked or abraded into the

adjacent cliff and been dislodged after many years of weathering. These finds are the most positive advance made in the study of Australian rock engravings. They lend strong support to the general hypothesis of great age for these attempts of prehistoric man to record aspects of the environment in which he lived.

The stone implements found on the three camp-sites associated with the Cleland Hills engraving site provide additional evidence of antiquity. The adze stones are only an indication of recent activity as such artefacts were in common use at the time of European settlement. Usually mounted in spinifex gum on the end of a curved piece of mulga they served for making a variety of wooden utensils and weapons (Spencer and Gillen, 1899). As supplies of stone were short in this region the examples found had all been repeatedly re-sharpened until they were of no further use. These implements were used over a wide area of Australia and have become known by the Wonkonguru term *tuhla* (Horne and Aiston, 1924).

Large trimmed core implements have been found at several rock engraving sites in South Australia (Edwards, 1964). Although the one example from near the engravings in the Cleland Hills does not provide substantial evidence of a direct connection it does justify a close search for these large, crude implements on camp-sites associated with Central Australian engraving sites. Cooper (1943) records a range of trimmed cores, some identical to the figured specimen (Fig. 9), concentrated on many South Australian sites, including Hallett Cove (Cooper, 1959), Kangaroo Island (Cooper, 1960) and the River Wakefield (Cooper, 1961). This industry is called *Kartan* in South Australia and is believed to be one of the earliest on the continent (Tindale, 1957). Its recognized distribution area has now been extended to the Macdonnell Ranges where a number have been found during recent field work. These finds will be the subject of a further paper.

Claims that the face engravings at Thomas Reservoir may be the product of a lost civilization are largely unsupported because of the predominance of motifs common to other sites and the lack of evidence of any age difference between the simple and detailed styles. These engravings add an exciting new style to the range of motifs recorded at Australian sites. This is not surprising for although consistent patterns of designs have been firmly established for some parts of the continent there remain vast regions yet to be examined in detail. Interpretation of the remarkable face engravings is made difficult by this lack of detailed studies. Further sites are certain to be found in the vast mountain ranges yet to be investigated in Central Australia. The discovery of these unique engravings illustrates in a dramatic way that an extension of the present field work could produce important results.

ACKNOWLEDGMENTS

The recording of the Thomas Reservoir site was initially due to Mr. Michael Terry whose persistence and enthusiasm led to the Cleland Hills expedition of 1967. His assistance and companionship in the field were much appreciated. My thanks are due to the Australian Institute of Aboriginal Studies for sponsoring the field work and inviting me to lead the investigations. The Principal, Mr. F. D. McCarthy, has given every encouragement to the project and made many helpful suggestions. A subsidy was provided by the Institute to enable publication of an adequate number of plates. The Director of Welfare, Northern Territory Administration, Mr. H. C. Giese, gave permission for the investigation. Invaluable assistance was rendered by Mr. Trevor Milikins, Superintendent of Areyonga Settlement, Mr. M. S. Maidns of Areyonga and Mr. D. G. Boerner of Alice Springs. Mr. D. J. Bannear of Cobdogla, South Australia, accompanied the expedition in a second Landrover at his own expense and provided valuable assistance in the field. Mr. Harry Bowshall made impressions of the engravings and Dr. D. W. P. Corbett identified the rock specimens. Mr. D. J. Mulvaney of the Australian National University kindly supplied details of dates obtained from the Ingaladdi Excavation. The South Australian Archives made available the manuscript journals of Maurice and Murray. Mr. Bruce Guerin read the manuscript and offered constructive criticism. The South Australian Museum provided equipment, salaries for two officers, and contributions to field expenses.

REFERENCES

Anati, E., 1963: *Palestine before the Hebrews.* London.

Arndt, W., 1962: The interpretation of the Delamere Lightning paintings and rock engravings. Oceania, 32 (3).

Bühler, A., 1948-49: Steingeräte, Steinskulpturen und Felszeichnungen aus Melanesien und Polynesien. Anthropos, 41-44.

Cooper, H. M., 1959: Large archaeological stone implements from Hallett Cove, South Australia. Trans. R. Soc. S. Aust., 82.

———— 1960: The archaeology of Kangaroo Island, South Australia. Rec. S. Aust. Mus., 13 (4).

———— 1961: Archaeological stone implements along the Lower River Wakefield, South Australia. Trans. R. Soc. S. Aust., 84.

Edwards, R., 1964: Rock engravings and stone implements of Pitcairn Station, North-eastern South Australia. Rec. S. Aust. Mus., 14 (4).

———— 1965: Rock engravings and aboriginal occupation at Nackara Springs in the North-east of South Australia. Rec. S. Aust. Mus., 15 (1).

———— 1966: Comparative study of rock engravings in South and Central Australia. Trans. R. Soc. S. Aust., 90.

Hale, H. M. and Tindale, N. B., 1930: Notes on some human remains in the lower Murray Valley, South Australia. Rec. S. Aust. Mus., 4 (2).

Heizer, R. F. and Baumhoff, M. A., 1962: *Prehistoric Rock Art of Nevada and Eastern California.* Berkeley.

Horne, G. and Aiston, G., 1924: *Savage Life in Central Australia.* London.

Kühn, H., 1956: *The Rock Pictures of Europe.* London.

Maurice, R. T., 1902a: Exploration journal from South to North Coast. Manuscript, S. Aust. Arch., Adelaide.

———— 1902b: Across the great thirst land. Manuscript, S. Aust. Arch., Adelaide.

McCarthy, F. D., 1962: The rock engravings at Port Hedland, North-western Australia. Pap. Kroeber anthrop. Soc., 26.

———— 1964: The Art of the Rock-faces. *Australian Aboriginal Art.* Sydney, 3.

McCarthy, F. D. and Macintosh, N. W. G., 1962: The Archaeology of Mootwingee Western New South Wales. Rec. Aust. Mus., 25 (13).

Mountford, C. P., 1960: Simple rock engravings in Central Australia. Man, 60 (192).

Murray, W. R., 1902: Exploration of R. T. Maurice, Fowlers Bay to Cambridge Gulf, Western Australia. Manuscript, S. Aust. Arch., Adelaide.

Spencer, B. and Gillen, F. J., 1899: *The native tribes of Central Australia.* London.

Slack, L. M., 1962: *Rock engravings from Driekops Eiland.* London.

Strehlow, T. G. H., 1964: The art of circle, line and square. *Australian Aboriginal Art.* Sydney, 4.

Terry, M., 1932: Erldunda Station—Laverton, Letter Book containing company correspondence. Manuscript, S. Aust. Mus., Adelaide.

Tietkens, W. H., 1890: Journal of Mr. W. H. Tietkens Central Australian exploring expedition. S. Aust. Parl. pap., Adelaide, 3.

Tindale, N. B., 1940: Distribution of Australian Aboriginal tribes: a field survey. Trans. R. Soc. S. Aust., 64 (1).

———— 1957: Culture succession in South Eastern Australia from late Pleistocene to the Present. Rec. S. Aust. Mus., 13 (1).

EXCAVATION OF ABORIGINAL GRAVES AT GIDGEALPA, SOUTH AUSTRALIA

By GRAEME L. PRETTY, Curator of Archaeology,
South Australian Museum

SUMMARY

Four aboriginal graves exposed by wind erosion were excavated. Two skeletons, one of them excavated from a bed of vegetation lining the grave, were dated by radiocarbon analysis. Some features of bone pathology are noted. A brief report of a fifth skeleton found at another site 30 kilometres distant is given.

INTRODUCTION

Through the courtesy of Delhi Australian Petroleum Ltd., I spent from 19-21 May 1964 at their Gidgealpa Location, accompanied by the Curator of Mammals, Mr. P. F. Aitken. We had been flown up to investigate a report of skeletons at Gidgealpa Water Hole.

On Wednesday, 20th, with Mr. Aitken, Dr. H. Wopfner (South Australian Department of Mines) and Mr. E. Siebel (Delhi Australian Petroleum) we travelled to the water hole, some 12½ km. north from the

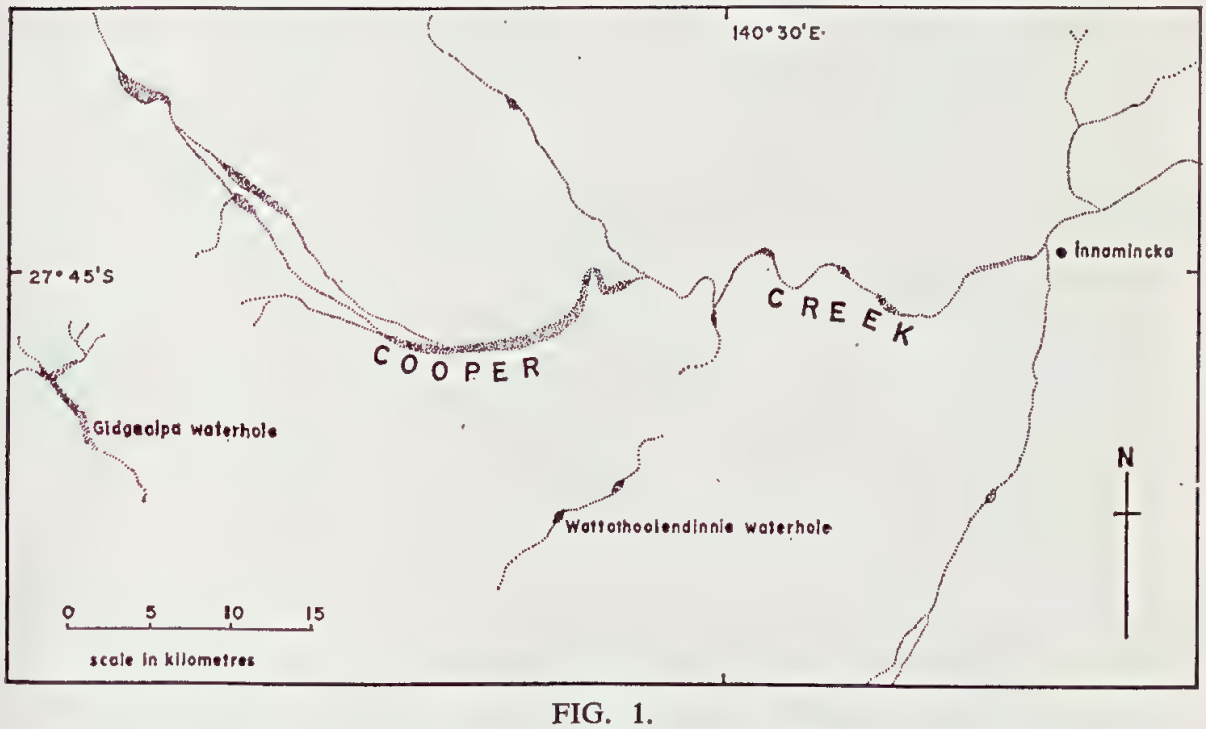


FIG. 1.
Part of Cooper Creek region showing localities mentioned in this paper.

drilling camp. Gidgealpa Water Hole (27° 49′ S, 140° 08′ E) is a remnant billabong of Cooper Creek which fills after flooding (see Fig. 1). It is part of the tribal territory of the Yandruwanta (Tindale 1940, p. 185, map) and the name is a corruption of Kilyalpa ['kiljalpə] which means "to stand in the shade of a grey rain-cloud", a reference to an incident in their creation stories (Vogelsang's translation of Reuther's MSS., Vol. 7, p. 112, No. 614).

EXCAVATION

There were four burials exposed in a deflated area of dune just beyond the southern bank of the water hole (Fig. 2). One was so badly broken up for its presence to be shown only by a scattered heap of bone fragments. The other three were about 5 m. apart and oriented in the same direction.

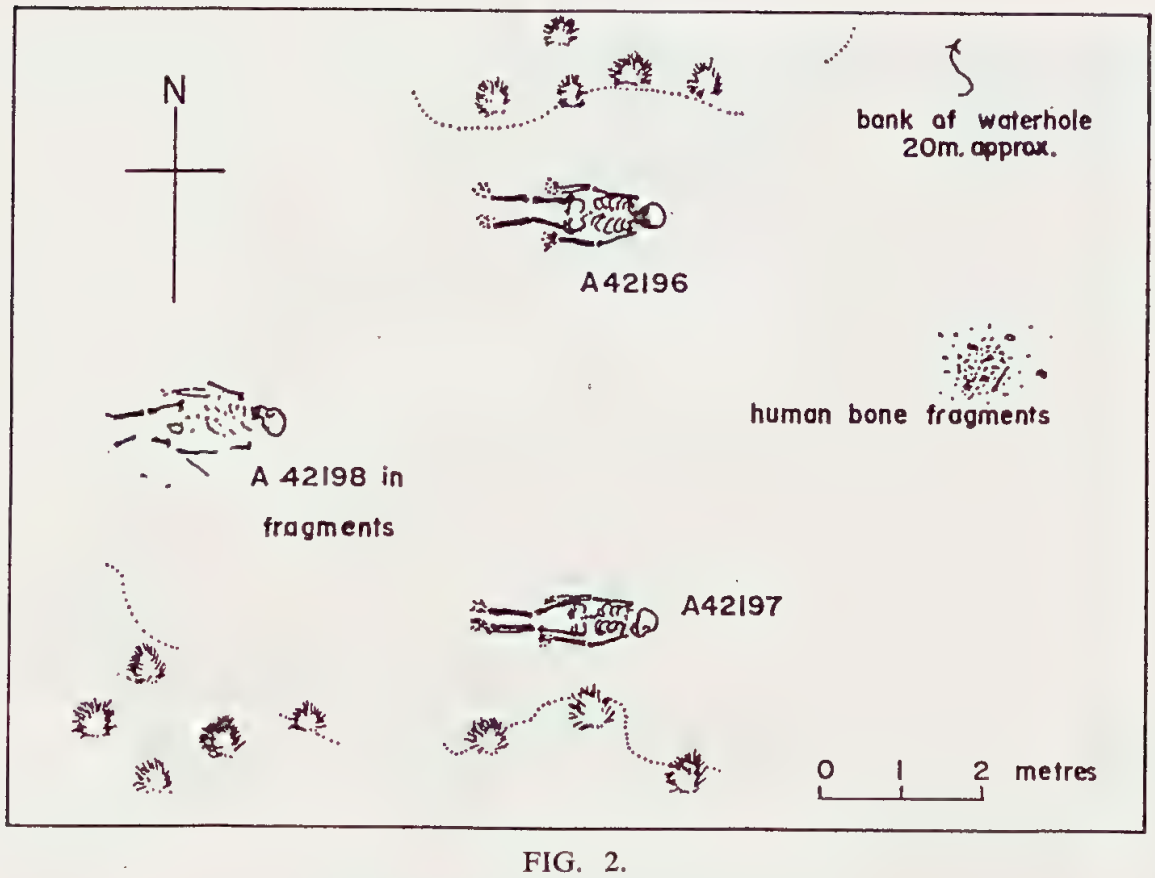


FIG. 2.
Plan of graves, Gidgealpa Water Hole.

All had been weathered and the bones were in a chalky, fragmentary state. The surrounding area and probably the full extent of the water hole banks would have been camped on by Aborigines. Stone implements and struck flakes were scattered through the sand and an old hearth was found on the surface among bushes not far from the graves.

Burial A42196* was of a male fully extended in a supine position, the skull having fallen forward until the chin rested on the sternum. Upon removal of the skull and upper vertebrae, a thin layer of dark vegetable matter appeared immediately beneath the backbone. It showed up in section as a gently curved layer (see Fig. 3A). The sand above it was flecked with dark humic matter which further clearing showed to be a dark oval extending from the skull to patellae. It would appear that the body had been laid on a matting of leaf brush before filling the grave. The dark mould was analysed and reported to contain predominantly leaf and twig remnants bearing a strong similarity to *Atalaya hemiglauca* F.v.M. The same plant still grows around the water hole (see Table 1). A sample of this material has been dated to 250 ± 90 B.P. by the Gakushuin Laboratory (Gak 678; see Table 2).

TABLE 1

LIST OF PLANTS COLLECTED AT GIDGEALPA WATER HOLE IN JULY 1964 BY J. GREER (DELHI AUSTRALIAN PETROLEUM)

Acacia oswaldii FvM.
Acacia victoriae BENTH.
Atalaya hemiglauca FvM.
Bauhinia carronii FvM.
Eucalyptus microtheca FvM.
Morgania glabra R.BR.
Muehlenbeckia cunninghamii (MEISN.) FvM.

Identifications courtesy Mr. P. G. Wilson, State Herbarium of South Australia.

Examination of the bones showed malunion of a fracture to the left radius and ulna. The interior of the calvarium contained a brown crumbly matter attached to the bone, the sandy contents of the skull having fallen away to expose it during cleaning. The absence of any similar material in the sand excavated from the outer surface would argue against its derivation from root matter. To test the possibility that it was tissue a strong extract was subjected to a Coomb's inhibition test. No trace of human globulin was detected.

Some fragments of flaked stone were found in the sandy fill of the grave, but as it is on a camp-site, they are more likely to have been part of the fill than to have been deliberately buried. No implements were recovered.

Burial A42197 was of a female and was also in a supine position. The skull was turned to the side facing towards its left. No layer of vegetation was detected beneath the skeleton. The grave lay close to the eroded edge of the original dune surface, marked by tufts of dry grass. If this can be taken as the dune surface at time of burial, then a line along the slope of the uneroded surface and directly over the skeleton gives an estimated grave depth of some 20 cm. Fragments of carbon from the fill

* The numbers cited are from the Museum Register.

have been dated to 320 ± 90 B.P. (Gak 679) by the Gakushuin Laboratory. It must be emphasized that this date was derived from lumps of charcoal collected from the sand between the bones. It is reasonable to suppose that it derived from campfires lit at the same time and swept into the grave with the sand, but it is possible that older carbon had been mixed with the sand, contaminating the grave. However, contiguity, conformity of alignment and mode of disposal, together with comparable condition of the weathered and exposed bones, combine to group these burials together. We may conclude that their time range would run from 250 to 320 B.P. ± 90 years.

TABLE 2

LIST OF C14 ASSAYS OF SAMPLES FROM GIDGEALPA WATER HOLE

Code No.	Sample	Age (years before 1950)
GaK-678 ..	No. A55838, vegetable matter lining grave pit of skeleton A42196	250 ± 90
GaK-679 ..	No. A55838, charcoal from grave fill of skeleton A42197	320 ± 90

Estimates from Prof. K. Kigoshi, Gakushuin University, Tokyo, in letter dated 7th October, 1965.

Examination of the skeleton shows lesions which suggest bone infection. There is a platform with osteophytes on the lower right tibia and some expansion in the proximal third of the left tibia. In the skull there is a noticeable depression of the sagittal suture accompanied by some porosity of the adjacent parietals. The suture fusion may be due to age. Although the lesions are not strongly characteristic, together they may raise the suspicion of treponemal infection.

No. A42198, 4.5 m. to the west of A and B, was also in the supine position, with the skull fallen to its right side. The bones were too fragmentary for successful removal, and only the skull was recovered.

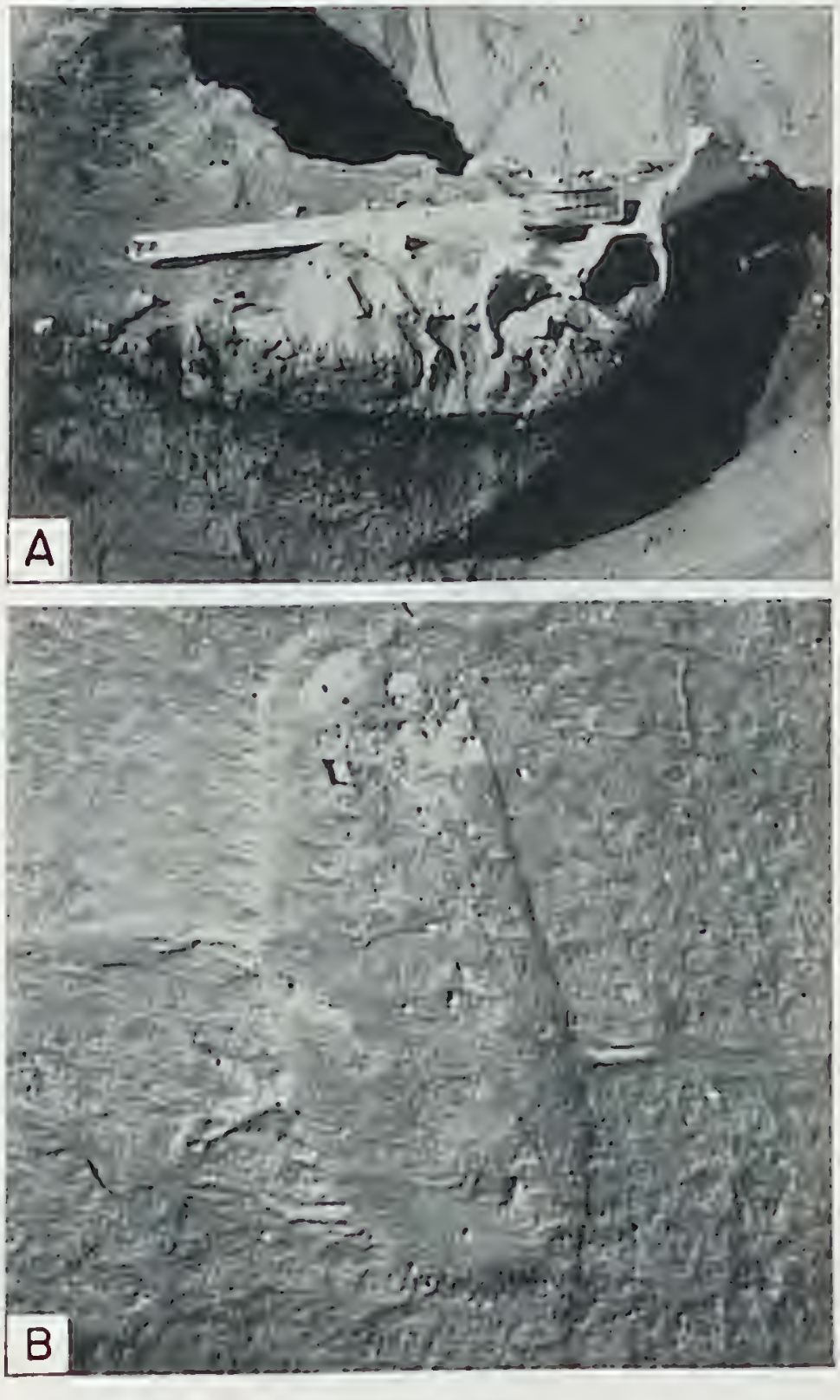
GRAVE AT WATTATHOOLENDINNIE WATER HOLE

An unexpected insight into the actual shape of grave pits in this area came from a grave discovered late in the same day at Wattathoolendinnie Water Hole some 30 kilometres east of Gidgealpa Location. Here, north of the track, sheet wash had swept away the overlying sand from the dune core (Wopfner and Twidale, 1967) exposing a fragmentary skeleton in a sub-rectangular pit, 180 cm. x 80 cm. (see Fig. 3B). The pit had been

FIG. 3.

A. Pelvis of A42196 exposed on a block to show the underlying matting of vegetation appearing in section as a gently curved dark band.

B. Grave at Wattathoolendinnie Water Hole showing the shallow depression left after erosion of the less compact fill. The matchbox near the head of the pit will serve as a scale.


A
B

dug into the indurated sandy loam, with differential erosion revealing its original shape. This can be seen from the photograph with the bone fragments appearing as scattered projections from the shallow depression. The skull, eroded away to expose its outline in section, can be seen to the right of the matchbox. The bones were too weathered to be removed and were left undisturbed. Basedow (1925, p. 205) refers to burials in oblong pits for this region.

Wattathoolendinne had also been a camp-site and a surface collection of stone implements included flaked *tula* chisels, worn *tula* slugs, long end-scrapers and grinding stones.

DISCUSSION

Yandruwanta burial customs are described by Howitt (1904, pp. 446-449), Basedow (1925, pp. 206-207) and Elkin (1937, pp. 280-289). Those for the neighbouring Dieri on the west are described by Gason (1874, p. 22), Berndt and Vogelsang (1939), and for the Wongkonguru to the north-west by Horne and Aiston (1924, pp. 152-153). The only reference to burial of the body on a matting of vegetation is for the Dieri by Berndt and Vogelsang (1939, p. 170). Basedow (1913) reports excavating a male skeleton covered with vegetation and lengths of wood at Bobmoony Well, east of Beltana (30° 48′ S, 138° 25′ E). This would be in the territory of the Kuyani, southern neighbours of the Yandruwanta (Tindale, 1940, p. 179, map).

According to MacPherson (1939, p. 177) branches of the water mallee (*Eucalyptus dumosa*) were buried at the feet of a body during burial at Ooldea, Nullarbor Plain, South Australia.

ACKNOWLEDGMENTS

I am thankful to Mr. G. Greer and Mr. George Higinbotham, Delhi Australian Petroleum, for arranging the visit, and to Dr. H. Wopfner (South Australian Department of Mines) for his assistance and information. The C14 estimates were obtained through a grant from the Board of Anthropological Research, University of Adelaide. Dr. R. N. Ibbotson, Institute of Medical and Veterinary Science, University of Adelaide, arranged for the Coomb's inhibition test and Mr. P. H. Smith, Department of Botany, University of Adelaide, analysed the humic matter from beneath A42196. I am indebted to Dr. C. J. Hackett, Royal National Orthopaedic Hospital, London, for examining the skeletons for bone pathology, and to Dr. D. R. Brothwell, British Museum (Nat. Hist.) for his comments.

REFERENCES

Basedow, H., 1913: Burial Customs in the Northern Flinders Ranges of South Australia. *Man*, 1913, No. 26, pp. 49-53, pl. D.

———— 1925: *The Australian Aboriginal*, Adelaide (pl. 25, opp. p. 196, pp. 206-207).

Berndt, R. M., and Vogelsang, T., 1939: Notes on the Dieri Tribe of South Australia. *Trans. Roy. Soc. S. Aust.*, 63 (2), pp. 167-171.

Elkin, A. P., 1937: Beliefs and Practices connected with Death in North-eastern and Western South Australia. *Oceania*, 7 (3), pp. 275-299, plates I-II, map. (March 1937.)

Gason, S. (ed. Isaacs), 1872: *The Dieyerie Tribe of Australian Aborigines,* Adelaide.

Horne, G., and Aiston, G., 1924: *Savage Life in Central Australia,* London.

Howitt, A. W., 1904: *The Native Tribes of South-East Australia,* London.

MacPherson, J., 1939: The Eucalyptus in the Daily Life and Medical Practice of the Australian Aborigines. *Mankind,* 2 (6), pp. 175-180, May 1939.

Reuther, J. G.: Manuscript and Map on the Tribes in the district east of Lake Eyre (translated from the German by T. Vogelsang) held in the South Australian Museum.

Tindale, N. B., 1940: Distribution of Australian Aboriginal Tribes: A field Survey. *Trans. Roy. Soc. S. Aust.,* 64 (1), pp. 140-231, with map.

Wopfner, H., and Twidale, C. R., 1967: Geomorphological History of the Lake Eyre Basin *in Landform Studies from Australia and New Guinea* (ed. Jennings, J. N., and Mabbutt, J. A.), Canberra.

ZUSAMMENFASSUNG

Vier durch winderosion freigelegte Gräber von Eingeborenen wurden ausgegraben. Zwei Skelette, eines davon auf einer Pflanzen-schicht ruhend, wurden mīttels des Radio-Carbon Prozesses datiert. Anzeichen von Knochen-Pathology sind festgestellt worden. Ein kurzer Report eines fünften Skeletts, an einer dreissig Kilometer entfernten Localität gefunden, ist ebenfalls beigefügt.

ABORIGINAL CAVE PAINTINGS AND ROCK MARKINGS AT INGALADDI ROCK SHELTER, WILLEROO, NORTHERN TERRITORY OF AUSTRALIA

By CHARLES P. MOUNTFORD and ERHARD J. BRANDL

This paper records cave paintings and rock markings on the walls and ceilings of a sandstone outcrop (Fig. 1), about 17 miles north, north-east of the Willeroo homestead, which, in turn, is 70 miles south-west of the Katherine railway station (Fig. 2).

These paintings have recently been photographed in detail by one of the authors (E. B.), and the illustrations and data prepared for publication by the companion author. Mr. J. Mulvaney and Mr. Robert Edwards have since carried out an archaeological excavation on this site.

Fig. 1. Cave painting site, Willeroo.

Fig. 2. Map of Northern Australia.

Although these examples of aboriginal art have been known for some time, there is not, to the best of our knowledge, any reference to them in anthropological literature.

DESCRIPTION OF CAVE PAINTINGS

Figure 3 illustrates three of the larger groups of cave paintings at Willeroo.

Painting A can be identified as a male kangaroo by the long tapering tail, protruding genetalia, and the shape of the head and ears. The artist has also shown both eyes on one side of the head. Below the kangaroo are two curious male figures, B, with body decorations and lines radiating from their heads (N, Fig. 4, and N, Fig. 6 are similar). As both the kangaroo and these two human figures appear to have been painted at the same time, they may be associated with an identical myth.

C, is an incomplete kangaroo, over-painted by the larger kangaroo at A. On the surface of C is a fresh-water tortoise. D, is a male dancing figure with protuberances on his shoulders and hips[1], and E an emu.

F, is a white man, probably a policeman, indicated by the hat and the two revolvers at G. In many other parts of the world the white man and his death-dealing gun have been linked together in the art of primitive man.

(1) These are "joint-marks" and will be discussed later.

Lips (1937, Chap. 4), has illustrated many examples; Mountford and Berndt (1939, p. 189), a Fijian bamboo flute on which soldiers and guns form the main decorations, and Mountford (1956, Fig. 49), a cave painting in western Arnhem Land illustrating a white man with a gun.

H and S, are large paintings of emus, their bodies decorated with splashes of white paint. On the body of each bird is a curious male dancing figure in white, *i.e.*, J, on the left-hand emu, and W, on the right. At K, is a white man riding a horse (see hat)[2]; the small figure to the right may be a foal.

Fig. 3. Cave paintings, Wi'leroo.

L, is a tortoise with its head obscured by the spiny ant-eater or echidna M. The bird N, is also partly covered by the echidna. At O, is a distorted and reversed dancing figure. Similar human designs have been recorded at Delamere (Davidson, 1936, Fig. 51); Beswick (Macintosh, 1952, p. 75, Fig. 2); Mountain Creek Waterhole (Mountford and Brandl, 1968, Fig. 5M), and Cape York (Mountford and Edwards, 1963 Field Notes). There

[2] In Australian aboriginal art a white man is usually identified by a hat (Mountford, 1955, Fig. 3, H and J.)

Fig. 4. Cave paintings, Willeroo.

is another human being at Q[3], and another with a large bent penis at R. U, is a dancing figure with up-raised arms and lines radiating from his head; T, an indecipherable design; Y, probably a kangaroo, and X a frog. V and Z, over-painted by the large emu design, are probably human figures.

The incomplete design at AA represents some form of reptile; BB, a footprint; CC, another footprint with six toes; DD, a human being with up-raised arms, and FF, a conventionalised drawing of an emu. EE, is an interesting and well-executed cave painting of a herd of 13 goats. These creatures are kept by the station owners to provide them with milk.

Figure 4 illustrates a number of isolated paintings at Willeroo.

A and B, are two faint human figures with their arms up-raised, and C, probably an echidna painted over a wheel-like design. Another eroded human figure D, is divided into three parts, the arms and legs on either side of a central line with a swelling at each end[4].

E, is a man and a woman holding hands; F, a long-necked bird, probably an emu; G, an unidentified creature; H, a fresh-water tortoise, and J a simple and incomplete human figure with up-raised arms.

K, is an unidentified bird-like design; L, a figure of indeterminate sex that partly obscures M, a cockatoo, and N, is a cave painting of two women with body decorations, although the breasts are not indicated. O, is a series of crescents and circles that may represent a human face, and P, an unidentified marsupial.

Painting A, on Fig. 6, is of unusual interest. In the first place it is a "heraldic woman" with the legs stretched upwards displaying the vulva (a deep gash cut in the soft rock), and secondly it has "joint-marks" (protuberances on both shoulders and knees), and a line extending from the fingers of each hand.

Similar figures holding loops of string between their fingers have been found in the rugged plateau country of western Arnhem Land by Mountford (1956, pl. 43E—two central figures—and pl. 57A).

According to the mythical stories of the aborigines, this rugged plateau is the home of many spirit people. They are of two kinds; the Mimis, shy, kindly folk of whom the aborigines are not afraid, and the Mamandis, who, being ill-disposed toward the natives, are always planning to do them harm.

One group of the Mamandis are the tall, thin-bodied Namarakains who are for ever seeking to steal the spirits of sick people to provide themselves with a meal (Mountford, 1956, p. 199). These people, mostly women, spend much of their time playing games with a loop of string between their

[3] The chevron designs on the body of this figure probably refer to body paintings, and the protuberances on the shoulders and hips to "joint-marks" (P.690).

[4] The "three-part" figure 4D, and the heraldic woman" design 6A, will be discussed later.

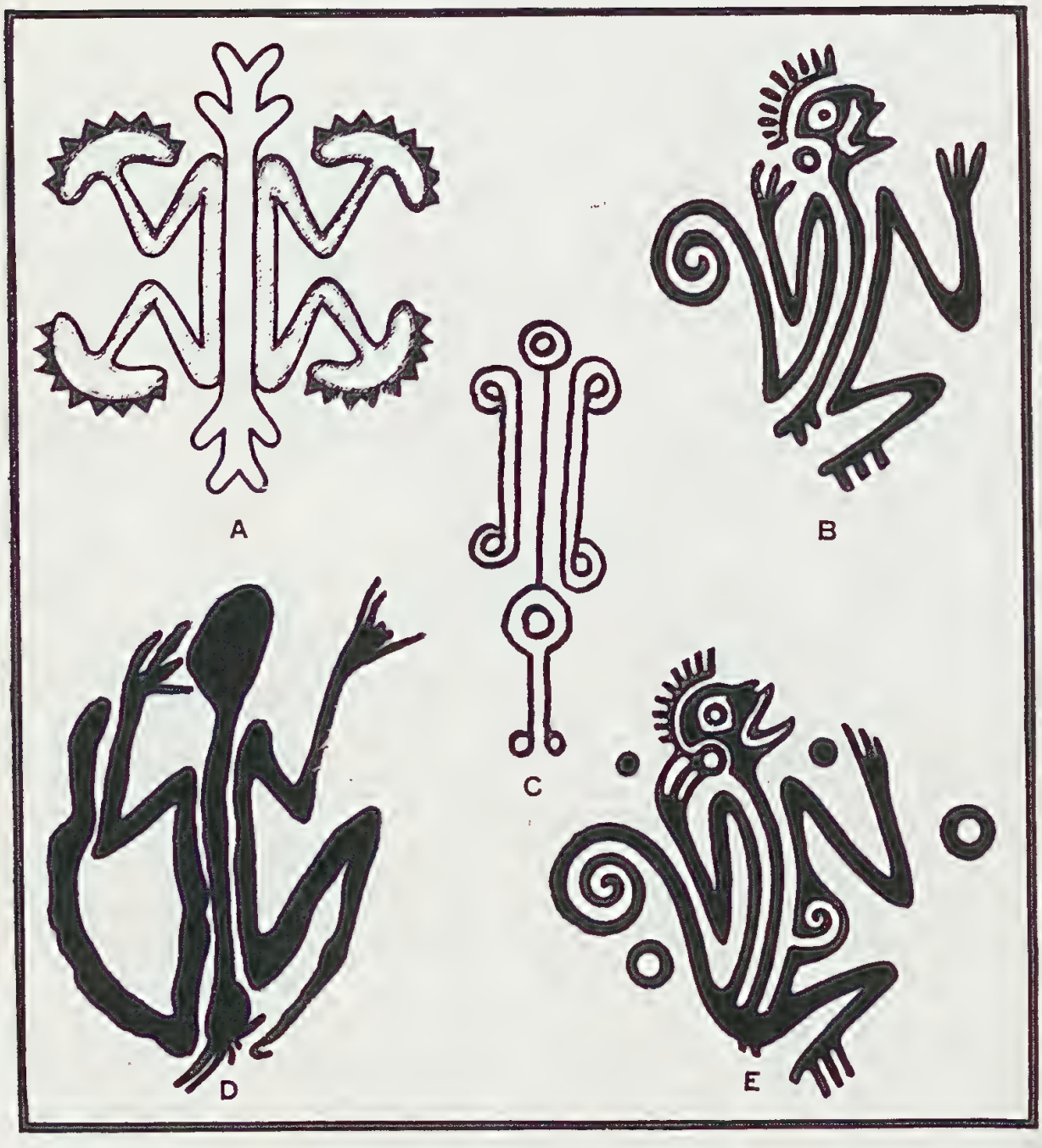


Fig. 5. Examples of three-part figure design: A, Tattooing pattern, New Guinea; B, Embossed clay plate, Mexico; C, Rock engraving, Papua; D, Cave painting, Sleisbeck, Australia; E, Stamp design, Vera Cruz, Mexico.

fingers. During the hours of darkness the women use the same loop of string to transport them from place to place. The painting (Fig. 6A) probably refers to a Namarakain woman.

B, a man and a woman copulating, has been painted over C, a faint human figure with a radiating head-dress. D, is an incomplete figure; E and J, eroded paintings of fresh-water turtles, and H a "heraldic woman" with characteristic "joint-marks" on a shoulder and knee.

Fig. 6. Cave paintings, Willeroo.

F, is another "heraldic woman" with circles on her body, and wearing a radiating head-dress; G, a crocodile, probably the fresh-water species; K, a badly-drawn and faint design of a kangaroo, and L, two incomplete human figures.

Design R, is a human figure, holding a stick; Q, is indecipherable; O and P, probably long-necked wading birds; M, a fresh-water tortoise, and N, a group of three men wearing body decorations and radiating head-dresses. These are similar to those associated with the kangaroo on Fig. 3, and the two at N, Fig. 4.

TECHNIQUES USED IN CAVE PAINTINGS

The techniques employed for painting the designs on the walls of the caves at Willeroo are probably as simple as those employed elsewhere, the pigments being red, yellow, and white ochres, and powdered charcoal or some black ore such as manganese or hematite. The brushes are likely to be similar to those used by the aborigines of Arnhem Land in the production

Fig. 7. Straight-line markings, Willeroo.

of their bark paintings (Mountford, 1956, Fig. 3), with the possible exception of the small flexible brush (Fig. 3, D, G, and H). There was no evidence that the finger was used as a brush at Willeroo, as it is in central Australia (Mountford, 1937, p. 435).

THE ROCK MARKINGS

There are also a large number of rock markings at Willeroo, the majority of them being groups of "straight-line markings", although there are a number of deeply-engraved footprints, and one of a boat.

Figure 7 illustrates a typical rock face covered with "straight-line markings". Many are arranged in groups of parallel lines (the usual form), and others with a number of cuts radiating from a common centre.

This type of rock marking is wide-spread. Basedow (1914, pl. 17) records a group at Mallett; Mountford (1928, p. 362) at Wabricoola and Winnininnie; Edwards (1964, pl. 14B) at Pitcairn, all in South Australia. Mountford (1960, Fig. 7) illustrates others at Ewaninga, central Australia; and Davidson (1936, p. 7, Fig. 2) at Delamere, south-west of Willeroo.

Fig. 8. Deeply engraved footprints, Willeroo.

Figure 8 shows a number of footprints, up to 1 inch deep, three human, three groups of wallabies or kangaroos, and one (on the extreme left), probably those of a wombat. Deeply engraved footprints such as these, have not been recorded from any other site in Australia.

Figure 9 is an engraving of a boat that does not resemble either an aboriginal canoe, the praus of the Malay trepangers, or any watercraft belonging to the white man. It is likely that the artist had never seen a boat, but made the engraving from a description given by another aboriginal. The two semi-circles on deck probably represent the hatches leading to the cabins beneath.

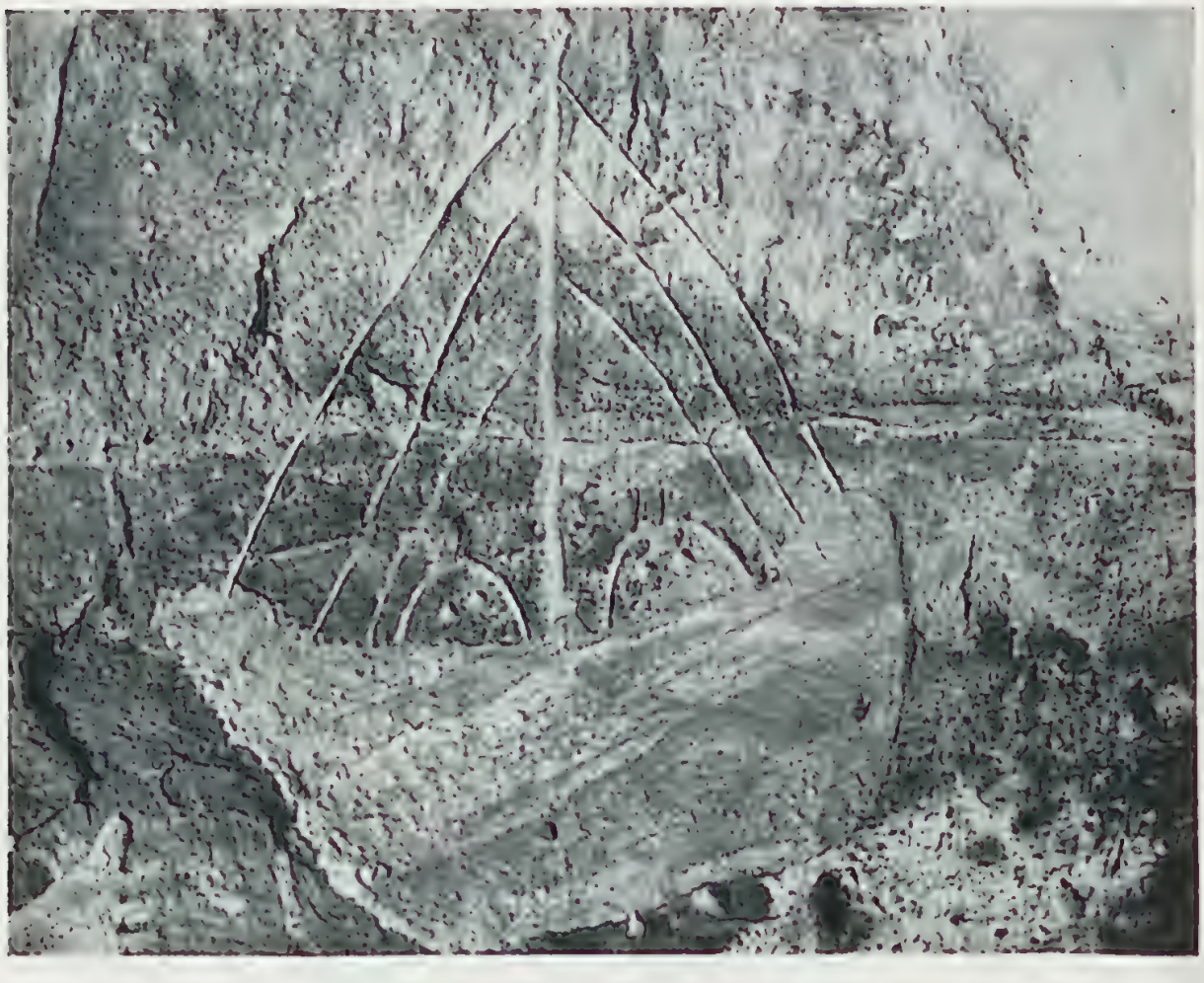


Fig. 9. Engraving of watercraft, Willeroo.

TECHNIQUES USED IN ROCK ENGRAVINGS

There is little doubt that the "straight-line markings" have been made with a stone axe, one of the authors (C. P. M.), having made identical marks with that tool (Mountford, 1928, p. 338). Also, as there is no

evidence of indentations suggesting that the "pecking techniques"[5] had been used to produce the other rock markings at Willeroo, it is likely that the deep footprints on Fig. 8, and the hull and the mast on Fig. 9, were made by pounding or rubbing the soft rock surface with a rounded pebble, and the rigging of the ship cut with a stone axe.

INTERPRETATIONS OF DESIGNS

Previous experience has shown that it is impossible to accurately interpret any example of aboriginal art, except the obvious representations of the creatures, without the aid of either the artist who produced them, or an informant fully conversant with the myth associated with the paintings. As there were no aborigines at Willeroo at the time these cave paintings and rock markings were photographed, we have only described the creatures, and drawn comparisons with identified paintings elsewhere. A great deal of harm has already been done by observers either recording their personal interpretations of cave paintings they have found, or by accepting the statements of aborigines who, having no first-hand knowledge of the meanings of the designs, were merely expressing their opinions. Recent experience has shown the danger of this form of enquiry (Mountford, 1965, p. 102); Mountford and Edwards (1964, p. 55).

There is no reasonable explanation, as yet, of the meanings and use of the multitude of "straight-line markings" at Willeroo and elsewhere.

DISCUSSION

The examples of aboriginal art at Willeroo, lying as they do, almost centrally between three major art areas, western Arnhem Land, central Australia, and the Kimberley region of north-western Western Australia, are of special interest.

There are no traces at Willeroo of the X-ray art of western Arnhem Land, nor of the curvilinear art of central Australia, *i.e.*, concentric circles, or meandering and loop-like designs. The only evidence of links with the Wandjina art of north-western Australia, are the lines radiating from the heads of some of the figures. This link, however, is doubtful because figures with radiating head-dresses have been found in such widely separated places as Gallery Hill, Western Australia (Mountford, 1965, Figs. 4, 6, etc.); Ayers Rock, central Australia (Mountford, 1965, Figs. 30, 36, 42); and northern Queensland (Field Notes, Mountford and Edwards, 1965).

[5] Most Australian rock engravings have been produced by striking the rock surface with a sharp-edged boulder, thus producing a series of pits or indentations that make up the design. (Mountford and Edwards, 1963, pls. 1 and 2).

There are, however, designs at Willeroo indicating an exotic origin, *i.e.*, the "joint-marks" (Fig. 6H); "heraldic woman" (Fig. 6A); and the "three-part figure" (Fig. 4D).

Schuster (1951, pp. 1-51), has recorded that these "joint-marks", in varying forms, extend from south-eastern Asia across the Pacific into central America, reaching their highest development in south-eastern Alaska, where each "joint-mark" becomes a human face (Schuster, 1951, Fig. 49).

These "joint-marks" appear to have a limited distribution in Australia having been found only at Cape York, Mountain Creek Waterhole, Oenpelli, and Willeroo. They are not, to the best of our knowledge, present at Beswick or Sleisbeck.

Frazer (1966, pp. 36-81), has recorded that the design of the "heraldic woman" who is usually shown with her legs apart exposing the pubic area, has a world-wide distribution. It is carved on the front of some English churches, and, in various forms it has been recorded throughout Europe, Africa, Asia, the Pacific area, and the Americas.

The same design has been found in the rock shelters of Cape York (Mountford and Edwards, 1963, Field Notes); the Oenpelli region of western Arnhem Land (Mountford 1956, pl. 52B, Fig. 29); Mountain Creek Waterhole (Mountford and Brandl, 1968, pl. 9J), and at Willeroo (Fig. 6A). We are using Frazer's term "heraldic woman", because it has already been established in literature.

The faint and somewhat eroded "three-part" human figure (Fig. 4D) also appears to be exotic in origin. Some years ago Mountford located and described a more complete figure of the same type (Mountford, 1958, pl. 9J), at Sleisbeck, except that the left leg had been extended to a tail (see Fig. 5D). As, at the time, the design had not been recorded elsewhere in Australia, the author illustrated the painting without comment. Sleisbeck is about 80 miles north-east of Willeroo.

A few years later, one of us (C. P. M.), purchased a Mexican clay dish embossed with a design (Fig. 5B) having many of the characteristics of the cave painting at Willeroo, and particularly at Sleisbeck. This suggested a link between the Australian "three-part" figures and those in other parts of the world.

On enquiring from Dr. Carl Schuster of New York about this particular motif (his famous collection of photographs of primitive art totals many thousands), he was able to locate a Mexican pattern recorded by Enciso (1947, pl. 118), as a "Flat stamp from Vera Cruz. They (the local artists), all use the monkey (Oxomatli), as a motif". The many points of resemblance between this design and the cave painting at Sleisbeck, are remarkable, separated as they are by about 8,000 miles of the Pacific Ocean.

Later, Dr. Schuster, when searching through his Melanesian collection of photographs, located two designs that appear to be somewhat related to the Australian examples, *i.e.*, Fig. 5C, a rock marking lightly engraved on a loose stone in the Wedau village of Papua (Williams, 1931, p. 134, Fig. 5), and a tattooing motif (Fig. 5A) in New Guinea (Schmitz, 1960, p. 160). Dr. Schmitz was unable to find out either the meaning or the name of the design.

As these three exotic designs in the cave paintings, *i.e.*, the "joint-marks", the "heraldic woman", and the "three-part human figure", have only been recorded from the north-eastern corner of Australia, it is reasonable to suppose that they reached this Continent through Melanesia, rather than through Indonesia. It is also possible that future research will show that these exotic designs will not extend much further west than Willeroo or Delamere.

SUMMARY

This paper describes cave paintings and rock markings at Willeroo, Northern Territory of Australia. The designs are illustrated, the probable techniques of production discussed, and where applicable, their origins and meanings noted.

ACKNOWLEDGMENTS

We wish to acknowledge the assistance we have received from several sources: to Mr. Hedley Brideson, the State Librarian of South Australia for the photographs that illustrate this article, and for the assistance of members of his staff, Mrs. Olga Hardy for preparing the drawings, and Mrs. Peggy Mountford for typing the manuscript; to Mr. Robert Edwards for the photograph of the Willeroo outcrop; to Dr. Carl Schuster for his assistance in locating the exotic designs on Fig. 5, and to Dr. Peter Crowcroft, the Director of the South Australian Museum, for accommodation and the facilities of his Museum.

REFERENCES

Basedow, H., 1914: Aboriginal Rock Engravings of Great Antiquity in South Australia. Jl R. anthrop. Inst., 44.

Davidson, D. S., 1936: Aboriginal Australian and Tasmanian Rock Carvings and Paintings. Mem. Am. phil. Soc., 5.

Edwards, Robert, 1964: Rock Engravings and Stone Implements of Pitcairn Station, north-eastern South Australia. Rec. S. Aust. Mus., 14 (4).

——— 1966: Field Work in the Northern Territory. Friends of the South Australian Museum Newsletter, 3.

Enciso, J., 1947: *Sellos del Antiguo Mexico.* Mexico.

Frazer, Douglas, 1966: *The Many Faces of Primitive Art.* New Jersey.

Goddard, R. H., 1941: Aboriginal Rock Sculpture and Stencilling in the Carnarvon Ranges. Oceania, 11 (4).

Lips, Julius, 1937: *The Savage Hits Back.* London.

McCarthy, F. D., 1960: The String Games of Yirkalla. *Records of the American-Australian Scientific Expedition to Arnhem Land.* 2.

Macintosh, N. W. G., 1952: Paintings in Beswick Creek Cave, Northern Territory. Oceania, 22 (4).

Mountford, C. P., 1928: Aboriginal Rock Carvings in South Australia. Rep. Australas. Ass. Advmt. Sci., 19.

———— 1937: Rock Paintings at Windulda, Western Australia. Oceania, 7 (4).

———— 1955: An Unrecorded Method of Aboriginal Rock Markings. Rec. S. Aust. Mus., 11 (4).

———— 1956: The Art, Myth and Symbolism. *Records of the American-Australian Scientific Expedition to Arnhem Land.* 1.

———— 1958: Aboriginal Cave Paintings at Sleisbeck, Northern Australia. Rec. S. Aust. Mus., 12 (2).

———— 1960: Simple Rock Engravings in Central Australia. Jl R. anthrop. Inst., 70.

———— 1965: Aboriginal Rock Poundings on Gallery Hill, north-western Western Australia. Rec. S. Aust. Mus., 15 (1).

Mountford, C. P. and Berndt, R. M., 1939: Ornamentation of a New Hebridian Flute. Victoria Nat., 55.

Mountford, C. P. and Brandl, E., 1968: Aboriginal Cave Paintings, Mountain Creek Waterhole, St. Vidgeon, Northern Territory of Australia. Rec. S. Aust. Mus., 15 (3).

Mountford, C. P. and Edwards, Robert, 1964: Rock Engravings in the Red Gorge, Deception Creek, Northern South Australia. Anthropos, 59.

Schmitz, Carl, 1960: Die Ornament der Komba auf New Guinea. Ethnologica, 2.

Schuster, Carl, 1951: Joint Marks as Possible Cultural Contact between America, Oceania, and the Far East. Royal Tropical Institute, Amersterdam. Commun. 44. Dept. Cult. and Phy. Anthrop., 39.

Schultz, R. S., 1956: North Western Australian Rock Paintings. Mem. natn. Mus. Vict., 20.

TWO MORE PREHISTORIC STONE ARTIFACTS FROM WESTERN PAPUA

By GRAEME L. PRETTY, Curator of Archaeology,
South Australian Museum

In a paper contributed to an earlier number (Pretty 1965), I have described two stone pestles from the Western District of Papua, discussing their possible place in the complex of stone implement distribution routes in this region, and their affinities with similar artifacts from elsewhere in Melanesia. Through the courtesy of Mr. R. D. Mackay, Preparator-in-Charge, Papua-New Guinea Public Museum and Art Gallery, two more specimens from this district have been brought to my attention. Both specimens are now in the Museum collections at Port Moresby.

ENGRAVED BOULDER FROM OLSOBIP

Figure 1 shows an engraved boulder somewhat elongated and gently tapering at each end. It measures 26 cm. x 18 cm. wide and weighs 6,576 gm. (14.5 lb.). There is no evidence of it being shaped in any way other than the engraving of a *motif* on one surface. This consists of two rude triangles opposed and joined at the apex where they frame a pair of circles. These latter have been formed in high relief by engraving around one rim and gouging out the centre. There is a small fleck 1.7 cm. long projecting from between them. The circles are quite deeply engraved but the lines of the enclosing triangles less so. Evidently the intention was to represent a human face.

The rock material is a poorly compacted soft siltstone with a limonitic stained crust yellow-brown in colour. The surface is faintly cracked and there are no clearly defined bedding planes.

It was presented to the Museum by Cadet Patrol Officer G. R. Leeson who recovered it while supervising the making of an airstrip at Olsobip (Olsivip) in October, 1964. Excavation of a deep hole disclosed the engraved stone beneath a large 1.2 m. diameter boulder from a depth of 2.4 m. Boulders of similar rock material are plentiful both in and on top of the surface but the bulk of the soil is made up of coralline encrusted boulders in a matrix of clay. The local people, the Faiwolmin, knew nothing about it. They claim relationship with the Telefolmin people and claim to have come south to Olsobip some time in the past (see map in Craig 1967).

Olsobip (5° 22′ S, 141° 31′ E) is 28.8 km. south of Telefomin in the Gum gorge. This gorge is part of the headwaters system of the Fly River.

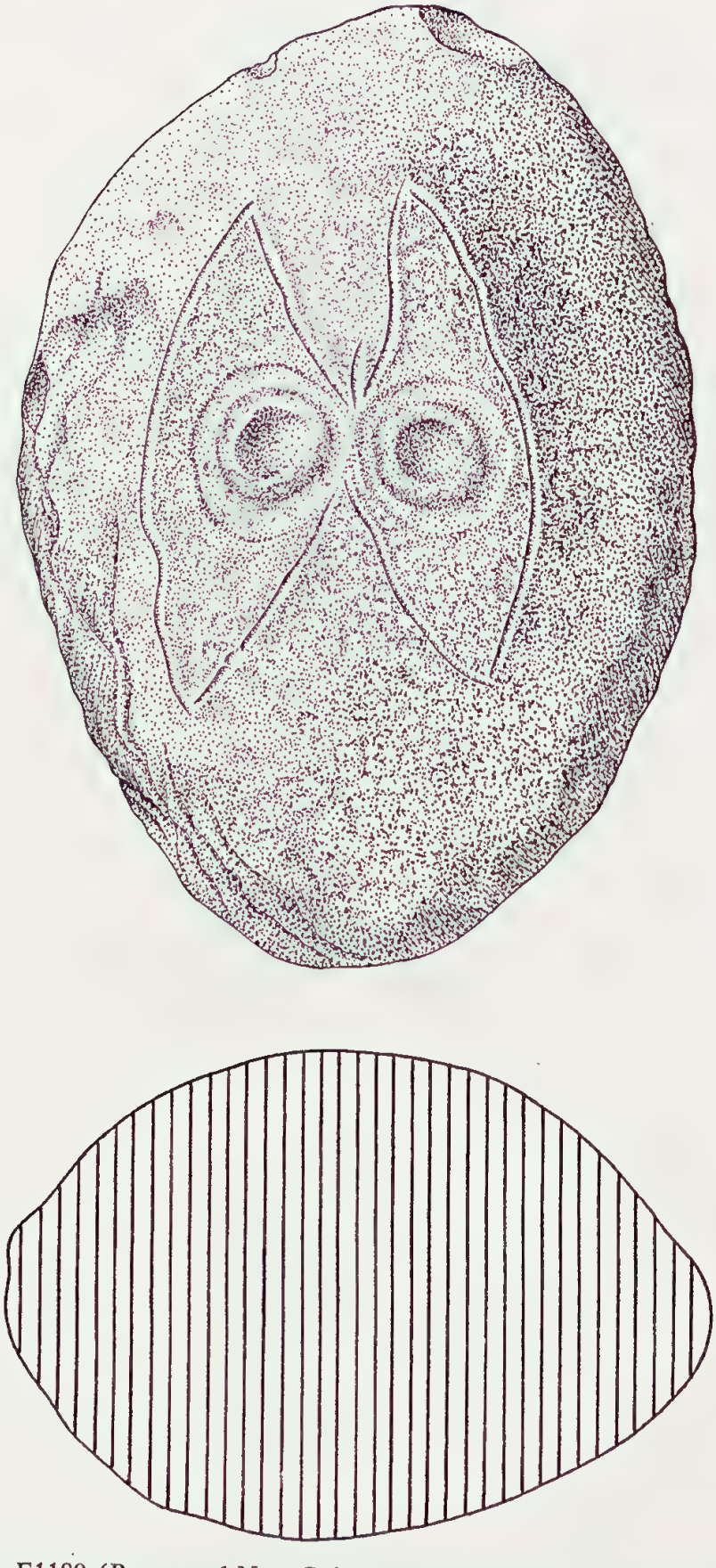


Fig. 1. E1189 (Papua and New Guinea Public Museum and Art Gallery): Engraved boulder from Olsobip. Slightly less than one-half natural size.

Mulvaney (1965) has described an engraved face chiselled into a boulder from the lower Sepik region. However it is a fairly complete delineation of the facial features and is quite distinct from the specimen described here where the treatment is highly schematic. Stylistically, the enclosing of the eyes in triangles in representations of the face is quite consistent for the woodcarving of the Huon Peninsula (Bodrogi 1961, pp. 159-161).

An archaeological stone pestle also from Olsobip, was described in the previous paper (Pretty 1965).

STONE BOWL FROM MOUNT BOSAVI

Figure 2 shows a deep stone bowl, or mortar, with a flattened base 28-30 cm. diameter and with sides sloping in to a rim 21-23 cm. diameter. Height from base to rim varies from 12-18 cm. It is hollowed out in the form of a cylinder with comparatively straight sides, of depth 9-11 cm., and a flat bottom 14 cm. diameter. It weighs 14,070 gm. (31 lb.).

The outside rim shows the faint traces of a shallow furrow encircling it 2.25 cm. below. For more than a third of its circumference it has been flaked away by a series of evenly directed blows along its edge. This has resulted in sub-conchoidal bulbar scars of fairly even dimensions. There is no evidence of flaking on the inside of the rim.

The rock material is a vesicular volcanic containing small crystals of dark minerals. The surface has weathered to an even grey. It is covered with what are judged to be pits of percussion left from hammer-dressing it to shape. There is no trace of finishing by grinding.

It was collected in April 1953 from the vicinity of Mount Bosavi (6° 35′ S, 142° 50′ E) by Patrol Officer C. T. Terrell of the then, Department of Native Affairs. Terrell found it beside the track on the further side of that branch of Wawi Creek which is closest to the village of Opai'ie (6° 44′ S, 142° 40′ S). The two Wawi creeks run from the south-western slopes of Mount Bosavi to join the Wawoi River, which flows south-eastward into the estuary of the Bamu. Opai'ie is on Ugo Creek which also runs into the Wawoi system.

Inquiries of the local people, the Wauru, elicited nothing in the way of information about the specimen. However, several similar objects were known of in the area.

This is the first report of a stone bowl from Western Papua. Presumably it is a mortar, and part of the prehistoric mortar and pestle complex now well known from Melanesia. One distinctive feature which separates it out from these is the cylindrical form of its hollowed out centre,

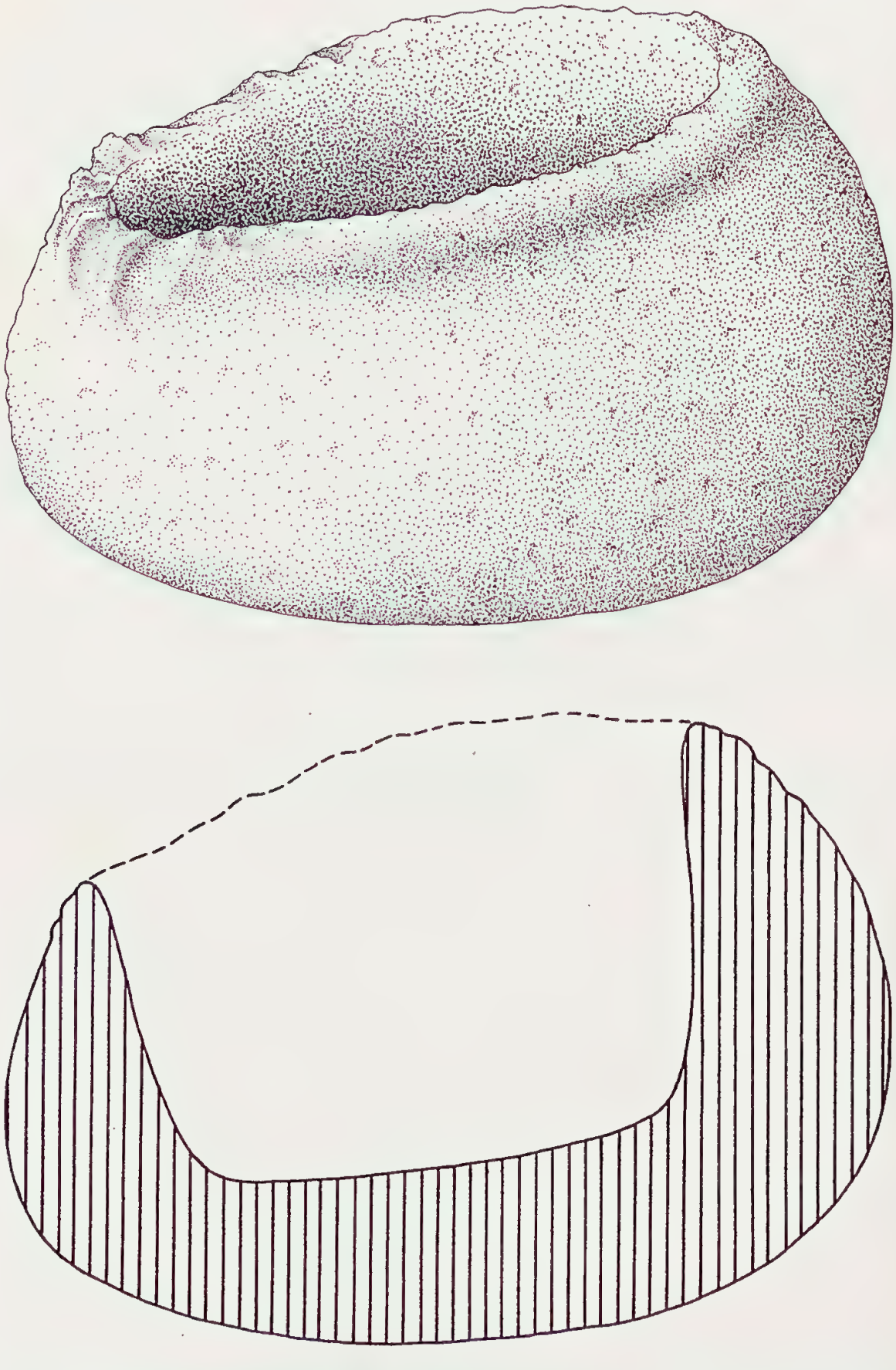


Fig. 2. E1291 (Papua and New Guinea Public Museum and Art Gallery): Stone bowl from Mount Bosavi. Slightly less than one-half natural size.

as against the semispherical to conical cup more usual for these artifacts. Its weight points to it having been still-standing not portable and in this it accords with the size and weight range of the prehistoric mortars. The series of flakes removed from the rim is curious. Perhaps they have been removed for use in sorcery which makes much use of unusual stone objects.

ACKNOWLEDGMENTS

I am grateful to the Board of Trustees, Papua and New Guinea Public Museum and Art Gallery for the loan of specimens and permission to publish this description. The drawings are by Brenda Hubbard.

REFERENCES

Bodrogi, T., 1961: *Art in North-East New Guinea.* Budapest.

Craig, B., 1967: The houseboards of the Telefomin Sub-district, New Guinea. *Man* (New Series), Vol. 2, No. 2, pp. 260-273.

Mulvaney, D. J., 1965: A carved stone face from the Sepik. *Journal of the Polynesian Society,* Vol. 74, No. 1, pp. 76-77, 1 pl.

Pretty, G. L., 1965: Two stone pestles from Western Papua and their relationship to prehistoric pestles and mortars from New Guinea. *Records of the South Australian Museum,* Vol. 15, No. 1, pp. 119-130, 2 pls.

HONEYEATERS RELATIVE TO NECTAR FEEDING ON KANGAROO ISLAND

*By J. ALLEN KEAST and HERBERT T. CONDON

A widely held fallacy is that most Australian honeyeaters are largely nectarivorous. This belief partly stems from observers being quick to record concentrations at times of peak flowering, but not providing data on feeding habits at other times.

During December, 1967 a comparative study was made of the feeding behaviour of nine species of honeyeaters (Family Meliphagidae) occurring on Kangaroo Island, South Australia. The Island was covered by means of transects and observations were made at about 70 different points, equal attention being paid to Mallee, Mallee heath, and forest habitats.

The species on which observations were made are listed in Table II. Additional forms have been recorded for Kangaroo Island, some being casual visitors and others open to doubt. In the first-named category are Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*) which was first observed during the RAOU campout in 1959, the nomadic White-fronted Honeyeater (*Phylidonyris albifrons*), and possibly the White-naped Honeyeater (*Melithreptus lunatus*) three specimens of which were collected by Zietz in the year 1901. Doubtful records are of the White-plumed Honeyeater (*Meliphaga penicillata*), which was claimed by J. B. Cleland and accepted by Sutton (1926) and the Singing Honeyeater (*M. virescens*), which may have been seen in Mallee near the south coast (Condon Ms., 1967). Notable absentees include the Noisy Miner (*Myzantha melanocephala*), Yellow-faced (*Meliphaga chrysops*), Yellow-faced (*M. ornata*)—a widespread Mallee species, and Black-chinned Honeyeater (*Melithreptus gularis*), which is a common species on the adjacent mainland.

Up to the present it has been generally accepted that members of the Island population of the Purple-gaped Honeyeater (*M. cratitia*) constituted a separate subspecies, which could be recognized by the presence of a *yellow gape* in adults. Specimens examined by the writers have shown that *lilac-gaped* individuals occur also.

Kangaroo Island is moderately rich in nectar-producing trees and shrubs of use to birds of many groups, including the Meliphagidae. According to a list of *Plants of Kangaroo Island* (unpublished, August, 1967) by Sir John Cleland, there are 23 species of the genus *Eucalyptus* but only two of *Banksia,* one of *Callistemon,* and one of *Amyema* (mistletoe). As in other areas, only a proportion of eucalypt species is of significance to birds.

* Queen's University, Kingston, Ont., Canada and South Australian Museum, Adelaide.

At the time of the survey, several of the major nectar-producers (namely *Eucalyptus diversifolia, E. pileata* and *E. cladocalyx*) and one of the bottle-brushes (*Banksia marginata*) were in full blossom, so that the responses of the birds to the availability of nectar might be regarded as typical for a flowering season. On the other hand, it was noted that most *Banksia marginata* and *Callistemon macropunctatus* were dry and with little nectar. Feeding from them was depressed accordingly.

Most numerous of the meliphagids on Kangaroo Island are the Purple-gaped and Yellow-winged Honeyeaters, the first-named in the remaining stands of dense Mallee and the latter more widely distributed but most common in Mallee heath. Least numerous are the Tawny-crowned Honeyeater, which is confined to low heath, and, rather surprisingly, the Little Wattle-Bird, only a few individuals of which were seen in the dry sclerophyll forest areas.

The results given here represent a summary of about 90 hours' field work at different times of the day, although most of the feeding data was obtained in morning and late afternoon.

At each study point, the species of honeyeaters present were located and their feeding behaviour assessed for periods of approximately three minutes. Where there were flowers, particular attention was paid to the response of each species to the blossoms. The major objective was to determine, quantitatively, the time each species spent in nectar- as opposed to insect-feeding. Where birds were visiting flowers, attention was given to whether individuals were actually holding the bill in a flower, that is drawing up nectar, or merely pecking in or around the bloom, as would be expected if only insects were being sought.

The proportion of time that a bird spends in taking nectar compared to insects does not, of course, necessarily give a true indication as to the dietary or nutritional importance of the two food items. A bird may be able to fill its stomach with nectar in a much shorter time than it can with insects or, on occasions, the reverse may be the case. Thus, whilst it is conceded that the data obtained might not always be valid, the observational method employed is the best available. Furthermore, it is difficult to sum the short periods of feeding activity in such quick-moving and erratic nectar-seekers as the Yellow-winged Honeyeater and Spinebill, both of which are continually on the move from flower to flower and tree to tree.

Results of observations made according to the methods outlined above are given in Table II. It should be pointed out that these observations were sufficiently comprehensive to arrive at a balanced assessment of nectar-relative to insect-feeding for the time of year, for all species listed except the Tawny-crowned Honeyeater and Little Wattle-Bird.

The Yellow-winged Honeyeater emerges as the most nectarivorous species and the Purple-gaped and White-eared Honeyeaters as the least. The difference in feeding habits between the two first-named was demonstrated on several occasions when they were together in blossoming trees, the Yellow-winged species working the flowers and the Purple-gaped Honeyeater concentrating on the leaves. At one clump of profusely blossoming *Eucalyptus pileata,* near Seal Bay, on the south coast, a dozen "Yellow-wings", four Red Wattle-Birds, and about 20 Rainbow Lorikeets (*Trichoglossus haematodus moluccanus*) were feeding on nectar, but a dozen Purple-gaped Honeyeaters, some with young recently out of the nest, never went near the blossoms. The White-eared Honeyeater, which occurred in Mallee and was common in the sclerophyll forest, was likewise never seen near blossoms, though at times it perched in *Banksia marginata,* from which a Spinebill was taking nectar and there were clumps of blossoming *Eucalyptus diversifolia,* attended by many nectar-feeders, nearby. The Brown-headed Honey-eater, which was moderately common in the Mallee and forest, paid no attention to blossoms, except for a solitary individual on one occasion; the species occurred without regard to flowering trees.

Contrary to what might be expected from its long bill, the Spinebill spent much more time obtaining insects from amongst the leaves of shrubs and saplings than it did at flowers. In contrast with the Yellow-winged Honeyeater, the Spinebill did not concentrate where there was blossoming, but was found to be dispersed throughout the forest, with only single individuals associating with the nectar-feeds on *Eucalyptus diversifolia* and *Eucalyptus pileata.* The Spinebill proved to be a somewhat "secretive" nectar-feeder, individuals commonly feeding from solitary nectar-producing trees or shrubs such as *Banksia marginata* in the forest and *Callistemon macropunctatus* in the heathland. At one site, a single flower head of a stunted *Banksia* was repeatedly visited by the birds.

Plants visited by the various honeyeaters are given in Table I. Rainbow Lorikeets occurred in flocks of up to several dozen on *Eucalyptus diversifolia* and smaller numbers obtained nectar from *Eucalyptus pileata.*

The wide variety of nectar-producing trees and shrubs attended by Yellow-winged Honeyeaters confirms the general impression that this is one of the most highly nectarivorous of the Australian honeyeaters. It contrasted with other species in that almost all individuals were concentrated in areas of flowering and in almost all groups of flowering gum trees. Even plants with small flowers and containing little nectar had some of these birds in the vicinity. Yellow-wings were very common also in *Banksia marginata* areas although, as noted, these blossoms contained little nectar at the time; the birds must have been feeding, to a considerable extent, upon insects.

A stand of the heathy shrub, *Adenanthos sericea,* situated on a barren hillside, had a community of these birds feeding extensively from the long, tubular flowers.

A search of back issues of *The Emu* and *The South Australian Ornithologist,* covering a period of 67 years, reveals a paucity of nectar-feeding observations on the Purple-gaped and White-eared Honeyeaters, there being only four records for the first-named—on Mallee eucalypts (Chandler, 1913; Ryan, 1951; Jones, 1952; Storr, 1947) and two for the last-named (Learmonth, 1958; Hunt, 1965). It may be mentioned also that the White-eared Honeyeater takes nectar from *Banksia* and *Angophora,* in the Sydney heathlands, on occasions. All the evidence suggests that these two species, without doubt, are mainly insectivorous.

Thanks are expressed to Mrs. M. Kenny, of the South Australian Museum staff, for kindly identifying the various plant species on which the honeyeaters were feeding.

TABLE I

Brown-headed Honeyeater, *Melithreptus brevirostris*—Feeding on *Eucalyptus cladocalyx.*

Crescent Honeyeater, *Phylidonyris pyrrhoptera*—Feeding on *Eucalyptus cladocalyx, Euc. diversifolia.*

Yellow-winged Honeyeater, *Phylidonyris novaehollandiae*—Feeding on *Eucalyptus diversifolia* (many places), *Euc. landsdowneana, Euc. leptophylla, Euc. pileata, Banksia marginata, Callistemon macropunctatus, Adenanthos sericea.*

Tawny-crowned Honeyeater, *Gliciphila melanops*—Feeding on *Callistemon macropunctatus.*

Eastern Spinebill, *Acanthorhynchus tenuirostris*—Feeding on *Eucalyptus diversifolia* (various places), *Callistemon macropunctatus, Banksia marginata.*

Red Wattle-Bird, *Anthochaera carunculata*—Feeding on *Eucalyptus diversifolia, Euc. pileata.*

TABLE II

Species	Number of individuals observed feeding	Number of occasions observed	Total feeding observations (in minutes) (approx.)	% time at blossoms	% time feeding elsewhere, *i.e.*, on insects
1. Purple-gaped Honeyeater, *Meliphaga cratitia*	120	43	65	—	100
2. White-eared Honeyeater, *Meliphaga leucotis*	52	18	40	—	100
3. Brown-headed Honeyeater, *Melithreptus brevirostris* . .	38	15	40	2	98
4. Crescent Honeyeater, *Phylidonyris pyrrhoptera* . .	17	7	15	15	85
5. Yellow-winged Honeyeater, *Phylidonyris novaehollandiae*	110	40	30	?(60)	40
6. Tawny-crowned Honeyeater, *Gliciphila melanops*	3	3	1	100	—
7. Eastern Spinebill, *Acanthorhynchus tenuirostris*	45	32	30	20	80
8. Little Wattle-Bird, *Anthochaera chrysoptera* . .	3	2	1	—(*)	100
9. Red Wattle-Bird, *Anthochaera carunculata* . .	25	11	20	15	85

(*) This species is normally nectarivorous, but the few individuals seen were not at blossoms.

LITERATURE CITED

Chandler, L. G., 1913: Bird-Life of Kow Plains (Victoria). *Emu,* 13: 43.
Hunt, A. C., 1965: Birds at a honeyflow. *Emu,* 64: 323.
Jones, J., 1952: The Hattah Lakes Camp-out, 1951. *Emu,* 52: 252.
Learmonth, N., 1958: Honeyeaters near Portland. *Emu,* 58: 257.
Ryan, J. V., 1951: Honeyeaters in the Bendigo district, Victoria. *Emu,* 51: 175.
Storr, G. M., 1947: Some birds observed on southern Eyre Peninsula. *South Austr. Orn.,* 18: 36.

ADDITIONS TO THE FROG FAUNA OF SOUTH AUSTRALIA

By DAVID S. WOODRUFF[1] and MICHAEL J. TYLER[2]

In a review of the frogs of South Australia Tyler (1966) reported 17 species occurring within that State and postulated that further species awaited discovery. The present contribution places on record the recent collection of two species representing additions to the fauna of South Australia.

Crinia laevis (Gunther)

A single specimen of this species was collected at Mount Burr near Millicent in south-eastern South Australia on 6 August, 1966 by Mr. H. Mincham (South Australian Museum R. 8118). One of us (D. S. W.) has subsequently been able to visit this locality and collect an additional specimen (Melbourne University Zoology Department 220/67). Study of a recording made of the mating call of a second individual which could not be collected confirms the identity of these specimens.

Crinia laevis had previously been known to exist in four disjunct populations in south-eastern Australia: Tasmania, King Island, and in the Grampians and extreme south-west of Victoria (Littlejohn and Martin 1964, 1965). Mount Burr is approximately 50 miles west of the nearest locality at which the species had been collected in Victoria (Dartmoor). In the absence of intensive collecting between these localities it remains uncertain whether *C. laevis* occurs throughout the intermediate area, or whether the South Australian population represents a fifth isolate.

The only *Crinia* previously known to occur in the lower south-eastern portion of South Australia was *C. signifera* (*vide* Tyler, 1966). From that species *C. laevis* can be readily distinguished by its smooth ventral surface. The ventral surface of *C. signifera* is granular. *C. laevis* may also possess distinctive light pink markings on the groin and legs. These spots, which are not invariably present in *C. laevis*, are never seen on *C. signifera*. The mating call of *C. laevis* has been characterized by Littlejohn and Martin (1964) and described verbally as "cra-a-a-a-a-ack, cra-a-ack, cra-a-ack, cra-ack, cra-ack . . .". At Mount Burr the males of this species were calling from beneath grass tussocks in ditches and clearings in the pine plantations.

Pseudophryne semimarmorata Lucas

Mr. E. R. Worrell collected this species at Dismal Swamp in South Australia several years ago (Worrell, 1963, pers. comm. to M. J. Littlejohn).

[1] Department of Zoology, University of Melbourne.
[2] South Australian Museum.

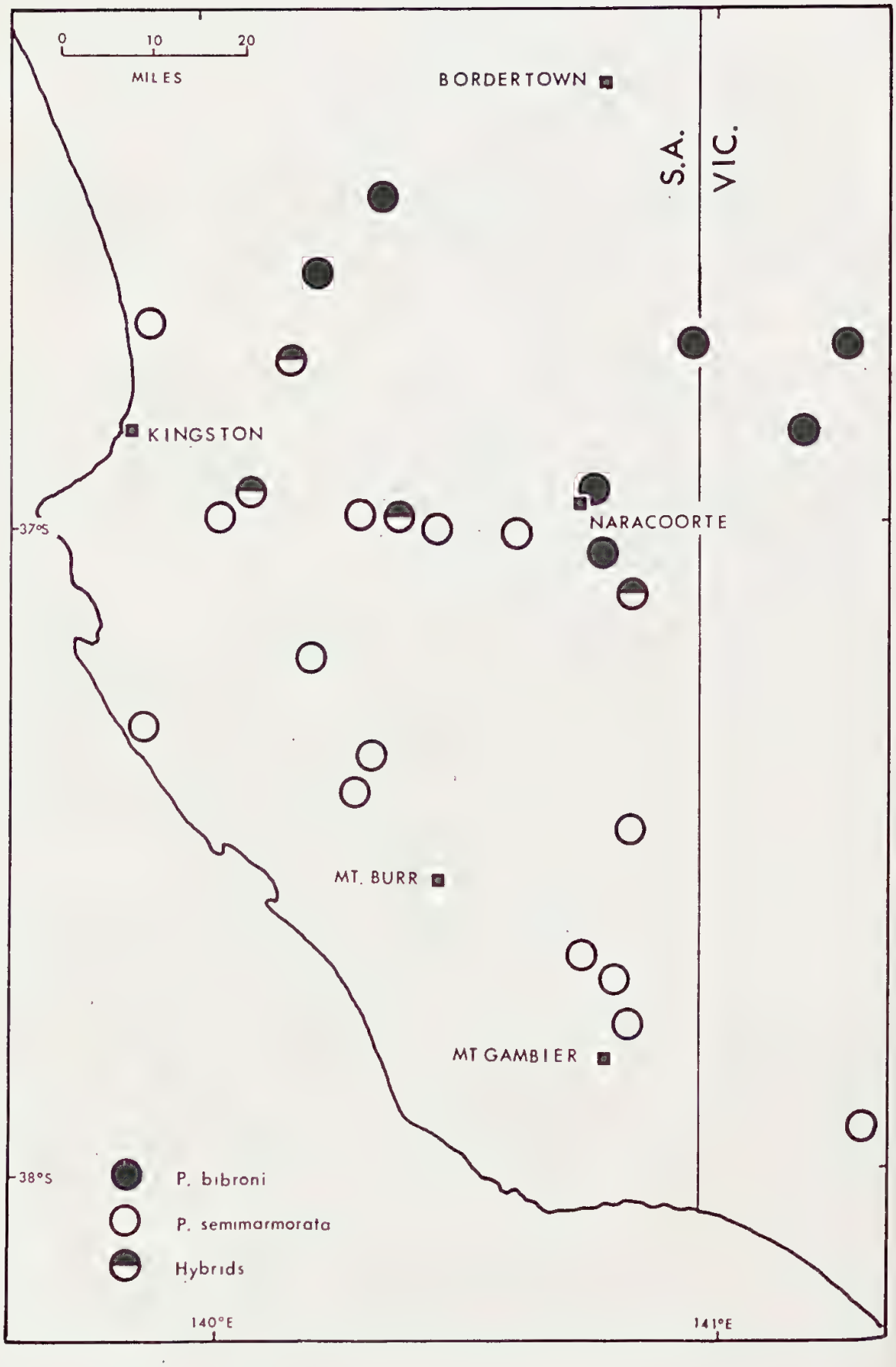


Fig. 1. Distribution of *Pseudophryne* in the lower south-east of South Australia.

Specimens have subsequently been collected at several localities in that State, and these records have been plotted in Fig. 1. The material is in the collections of the Zoology Department, University of Melbourne, and the South Australian Museum.

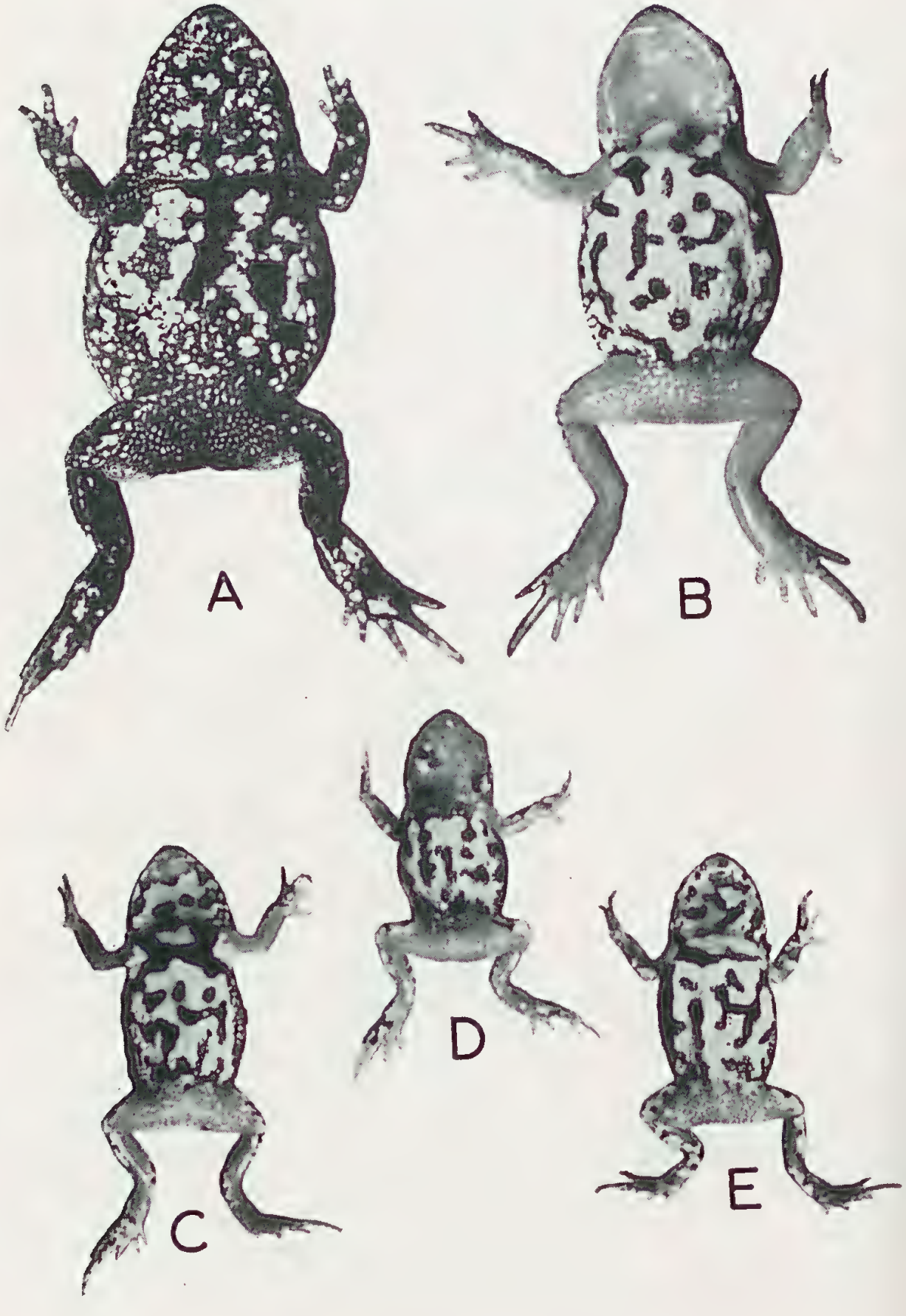
P. semimarmorata is restricted to south-eastern Australia having four disjunct populations. It has previously been recorded in east and central coastal Victoria, from Melbourne east to Orbost; in Tasmania; Flinders Island; and in western coastal Victoria from the Otways west to the Grampians and Portland district (Littlejohn and Martin 1965). The collections reported here constitute a range extension of approximately 130 miles and a new record for South Australia. The species is probably distributed in suitable habitats throughout the region.

To the north of the range of *P. semimarmorata* in western Victoria and in South Australia the closely related *P. bibroni* occurs. The ventral surface of *P. bibroni* is dark-brown or black mottled with white. In *P. semimarmorata* the undersides of the limbs and to a varying extent the throat and groin are not mottled but yellow or flesh-coloured (Fig. 2). In both species the pattern and degree of mottling on the ventral surface is highly variable. In Victoria the ranges of these two species are contiguously allopatric and a narrow zone of hybridization characterized by frogs of intermediate coloration has been found (Littlejohn 1963, 1967). A similar situation evidently occurs in South Australia with the site of the zone of hybridization currently based on specimens from the four localities recorded in Fig. 1. Three specimens from one of these localities are shown in Fig. 2.

The breeding behaviour, life history and larval morphology of *P. semimarmorata* and *P. bibroni* are essentially similar (Littlejohn 1963, Martin 1965).

DISCUSSION

The discovery of the westernmost populations of *Pseudophryne semimarmorata* and *Crinia laevis* is of zoogeographical interest in that it supports the general pattern of the distribution of Bassian faunal elements west into the south-east corner of South Australia. Such distribution patterns characterize the western boundary of the Bassian subregion and are seen in a variety of organisms including several other anurans (Littlejohn 1967). These peripheral populations are of ecological and evolutionary significance in that they represent the present-day adaptational limits of Bassian taxa. The apparently disjunct populations of *C. laevis* suggest that its distribution may have been more extensive in the past and that environmental factors are limiting today. On the other hand the persistence of the hybrid zone between *P. bibroni* and *P. semimarmorata* suggests that the northern extension of the latter is limited by biotic factors in the main.


A
B
C
D
E

ACKNOWLEDGMENTS

One of us (D. S. W.) is indebted to Dr. M. J. Littlejohn for advice and guidance and was assisted by a Melbourne University Research Grant and later a Commonwealth Postgraduate Award. The following have given field assistance: M. J. Littlejohn, A. A. Martin, R. A. Rawlinson, I. J. Crick and D. Von Behrens.

LITERATURE CITED

Littlejohn, M. J., 1963: Frogs of the Melbourne area. *Vict. Nat.*, 79: 296-304.

———— 1967: Patterns of zoogeography and speciation in south-eastern Australian amphibia. Chapter in A. H. Weatherley (ed.) *Australian Inland Waters and Their Fauna: Eleven Studies.* A.N.U., Canberra.

Littlejohn, M. A. and Martin, A. A., 1964: The *Crinia laevis* complex (Anura: Leptodactylidae) in south-eastern Australia. *Aust. J. Zool.*, 12: 70-83.

———— 1965: The vertebrate fauna of the Bass Strait islands: 1. The amphibia of Flinders and King Islands. *Proc. Roy. Soc. Vict.*, 79: 247-256.

Martin, A. A., 1965: Tadpoles of the Melbourne area. *Vict. Nat.*, 82: 139-149.

Tyler, M. J., 1966: *Frogs of South Australia.* South Australian Museum, Adelaide.

Fig. 2. Ventral markings of the two species of *Pseudophryne* known from South Australia. A. *P. bibroni.* B. *P. semimarmorata.* C, D, E. Ventral view of the *Pseudophryne* hybrids collected 2.5 miles east of Reedy Creek, South Australia. Ventral coloration is intermediate between *P. bibroni* and *P. semimarmorata.* Hybrid populations are also characterized by increased morphological variation.

A TAXONOMIC STUDY OF HYLID FROGS OF THE HYLA LESUEURI COMPLEX OCCURRING IN NORTH-WESTERN AUSTRALIA

By MICHAEL J. TYLER, Honorary Associate in Herpetology, South Australian Museum

INTRODUCTION

The *Hyla lesueuri* complex, as defined by Moore (1961), comprises a group of terrestrial species exhibiting a sequence of habitus, "that begins with stout-bodied and broad-headed forms and gradually passes to those with extremely slender bodies, long legs and narrow heads". Moore was primarily concerned with the five members of the complex occurring in New South Wales: *booroolongensis, freycinetti, latopalmata, lesueuri,* and *nasuta,* but examined species from other States and drew attention to several taxonomic problems associated with the identity of specimens from northern Australia. Moore had examined specimens from the Northern Territory identified as *nigrofrenata* by Kinghorn (1931) and, although unwilling to associate them with that species, considered that they differed in certain respects from *lesueuri* to which Copland (1957) had referred them. Accordingly, Moore's list of the representatives of the complex occurring in northern Western Australia and the Northern Territory recorded *latopalmata* and *nasuta* in both areas plus either *nigrofrenata* or *lesueuri* in the latter.

Hosmer (1964) described *Hyla spaldingi* a new species of the complex from the Northern Territory and suggested that material examined by Moore, and other records of *lesueuri* from this region, were probably based on *spaldingi.*

Several large collections of *Hyla* from northern parts of Western Australia and the Northern Territory were found to include four widely distributed species that were clearly members of the *lesueuri* complex. As one represented what appeared to be an undescribed species, the type specimens of species of northern Australian origin synonymised within the complex were examined to confirm their status. The only Queensland and New South Wales members of the complex reported here are those common to Western Australia and the Northern Territory, thus minimizing repetition of data presented by Moore (1961).

MATERIALS AND DESCRIPTIVE METHODS

The 310 specimens reported here are lodged in museum collections abbreviated as follows:—Australian Museum (A.M.); American Museum of Natural History (A.M.N.H.); British Museum (Natural History) (B.M.);

Museum of Comparative Zoology (M.C.Z.); Naturhistoriska Riksmuseet (N.R.); South Australian Museum (S.A.M.); United States National Museum (U.S.N.M.); Western Australian Museum (W.A.M.). Letters preceding registration numbers refer to departmental catalogue references, and numbers in parentheses following registration numbers indicate specimens catalogued collectively under a single number.

The following abbreviations appear in the text and tables:—E-N/IN (ratio of the eye to naris distance to the internarial span); HL/HW (head length to head width ratio); HW/S-V (head width to snout to vent length ratio); and TL/S-V (tibia length to snout to vent length ratio). Methods of measurement and descriptive techniques conform to those employed for *Hyla* by Tyler (1968).

Most literature references cited in the synonymies refer at least in part to Western Australian or Northern Territory specimens.

MORPHOLOGICAL CRITERIA

All of the 13 morphological features by which Moore (1961, p. 310) distinguished New South Wales members of the *lesueuri* complex, are equally suitable for distinguishing those occurring in northern Australia. However, even in those species which have the most distinctive habitus (*e.g.*, *Hyla nasuta*) there are few unique characters and it is necessary to compare at least three or four to provide an objective identification. Thus it is desirable to draw attention to the advantages and disadvantages of some of them.

In each species the posterior surface of the thighs bears an irregular pattern of light and dark markings. These markings are liable to fade in preservative for Andersson (1913) reported that in *affinis* they were, "more or less marbled with black and white", whereas the same specimens are now marbled with light brown on a dull yellow background. It was Andersson's descriptive notes which led Copland (1957) to erroneously conclude that the specimens were examples of *latopalmata watjulumensis*. In at least one member of the complex the thighs are marbled with brown on a yellowish background in freshly preserved material.

There is frequently considerable intraspecific variation in the ratios of head length/head width, tibia length/snout to vent length, etc., as illustrated in Tables 1 and 2. However, plotting series in the form of point frequency diagrams during initial studies (*e.g.*, Fig. 3) provided means of separating populations prior to more detailed examination.

The extent of development of terminal digital discs and the presence or absence of circum-marginal grooves differs markedly between some species.

Particular emphasis has been placed upon this feature, as it proved of considerable value in distinguishing the sexually immature specimens which formed the bulk of most collections. No indications of ontogenetic trends have been noted.

ACCOUNT OF SPECIES

Hyla wotjulumensis Copland

Hyla lesueurii, (part) Copland (1957), p. 92.

Hyla latopalmata watjulumensis (part) Copland (1957), Proc. Linn. Soc. N.S.W., **82** (1), p. 96.

Hyla spaldingi Hosmer (1964), Amer. Mus. Novit., No. 2182, p. 2, figs. 3-4.

Emendation of Specific Name: The spelling of the stem of the subspecific name and the type locality from which it is derived are in error in the original description. Glauert (1959) refers to the locality as Wotjulum and it is spelt that way on maps. The taxon is therefore emended to *wotjulumensis* in accordance with the provisions of Article 33a of the International Code of Zoological Nomenclature.

Types: Regrettably none of the 36 specimens examined by Copland are specifically designated as types. However, in a discussion following a list of the specimens examined and literature records considered to be based on this subspecies, he refers to "Watjulum Mission", as "the type locality". Twenty-nine specimens are listed from that locality and these are subsequently referred to here as the syntypes: W.A.M. 11195-9, 11633-5, 11638, 11896-11907, 11932-9. One (R.11195) is an extremely dehydrated specimen of *Hyla peroni*, and three more (R.11197, 11638, 11939) are representatives of a new species described in the present paper; these are therefore excluded from further consideration. Another complication is caused by two specimens bearing tags with identical registration numbers (R.11897). There is no indication which was examined by Copland, and the total of 29 precludes one of them. One has therefore been allotted a new catalogue number (R.29763) and is not regarded a syntype. Selection for re-registration was purely arbitrary and does not materially affect the definition of the species in any way. Several further specimens have not been found with the result that the following data are based on only 18 of the syntype series, namely: W.A.M. R.11198-9, 11633, 11896-9, 11901-3, 11906-7, 11932-3, 11935-8. The syntypes were collected by K. G. Buller and A. M. Douglas. The dates of collection are unknown.

Seventeen of the syntypes are females with a snout to vent length range of 45.7-54.1 mm. The TL/S-V, E-N/IN and HL/HW ranges and means are recorded in Table 1.

TABLE 1

Ratios and Measurements of *Hyla wotjulumensis*, *Hyla nasuta* and *Hyla coplandi*

	F	TL/S-V	E-N/IN	HL/HW	Adult Size (S-V in mm.)	
					♂♂	♀♀
wotjulumensis						
Syntypes	18	.593-.704 (.654)	1.000-1.178 (1.069)	1.056-1.260 (1.144)	—	45.7-54.1
Kalumburu.....	4	.633-.714 (.673)	1.000-1.044 (1.019)	1.057-1.220 (1.148)	33.8	45.2
Katherine	6	.673-.699 (.686)	.929-1.025 (.962)	1.120-1.169 (1.146)	—	—
90m.N. of Mainoru ..	15	.603-.732 (.683)	.918-1.170 (.994)	1.080-1.204 (1.148)	33.3.-35.7	45.4-51.8
nasuta						
All specimens	13	.643-.779 (.698)	1.000-1.188 (1.139)	1.206-1.429 (1.285)	31.4-32.1	36.2-42.8
coplandi						
Inverway Station	7	.535-.618 (.581)	.949-1.120 (1.020)	1.042-1.131 (1.075)	33.3-34.7	38.8
Wave Hill	9	.525-.641 (.584)	.920-1.077 (1.009)	1.025-1.144 (1.067)	33.4-33.5	40-40.2
Kalumburu.....	4	.577-.631 (.608)	1.000-1.118 (1.065)	.985-1.105 (1.030)	33.8-34.8	35.2
Bugle Gap	5	.542-.634 (.602)	.974-1.088 (1.030)	1.035-1.093 (1.069)	31.2	35.7-37.9
23m.S.S.E. Wyndham.	5	.592-.630 (.610)	1.000-1.063 (1.031)	1.014-1.097 (1.043)	—	38.3

Synonymy: The holotype of *Hyla spaldingi* Hosmer (1964) has been examined and the species is referred to the synonymy of *wotjulumensis*.

Additional Material Examined: 83 specimens:—

Western Australia—

Kalumburu—W.A.M. R.13752D, 13754, 13759A, 13759C-G, 13761.

Noonkanbah, Fitzroy River—W.A.M. R.26199.

Parry Creek—W.A.M. 29568.

Wotjulum Mission—W.A.M. R.29763.

Northern Territory—

Coomalie Creek (16m. N. of Adelaide R.)—W.A.M. R.26245.

Elizabeth River (50m. S. of Darwin)—W.A.M. 23886 (formerly A.M.N.H. 67835), holotype of *H. spaldingi*.

Katherine—S.A.M. R.4876; W.A.M. R.26136-40.

55m. N. of Mainoru—S.A.M. R.9132(13).

73m. N. of Mainoru—S.A.M. R.9038-40.

90m. N. of Mainoru—S.A.M. R.9046-60.

98m. N. of Mainoru—S.A.M. R.9041-45, 9086-96.

Yam Creek—A.M. R.4914, 4916, 4918, 4921, 4926.

Descriptive Notes: Measurements of several of the series listed above are included in Table 1. The combination of fully webbed toes and a broad continuous lateral head stripe, uninterrupted behind the tympanum, distinguishes this species from other members of the complex. The pre-ocular

portion of the head stripe extends from the tip of the snout, and continues as a narrow line along the inferior margin of the tympanic annulus, and proceeds in a straight line to a point beyond the axilla. The superior margin of the postocular portion is on a level with the position usually occupied by a supratympanic fold (absent in this species). The head stripe is black, the contrast against the background being determined by the density of the chromatophores.

The dorsum varies from pale olive to dark grey with or without faint suffusions or mottling of darker pigment. A trace of a faint, broad transocular bar is visible in most specimens. The throat is white or stippled with isolated melanophores, densest on the mandibular border where they are interrupted by a few large, circular islands of very pale cream. The backs of the thighs are usually pale yellow heavily reticulated with irregular black or dark grey markings.

Distribution: The known geographic range of *wotjulumensis* extends over a distance of approximately 1,000 miles between Wotjulum and Red-Bank Mine near Wollogorang (cited for *spaldingi* by Hosmer, 1964).

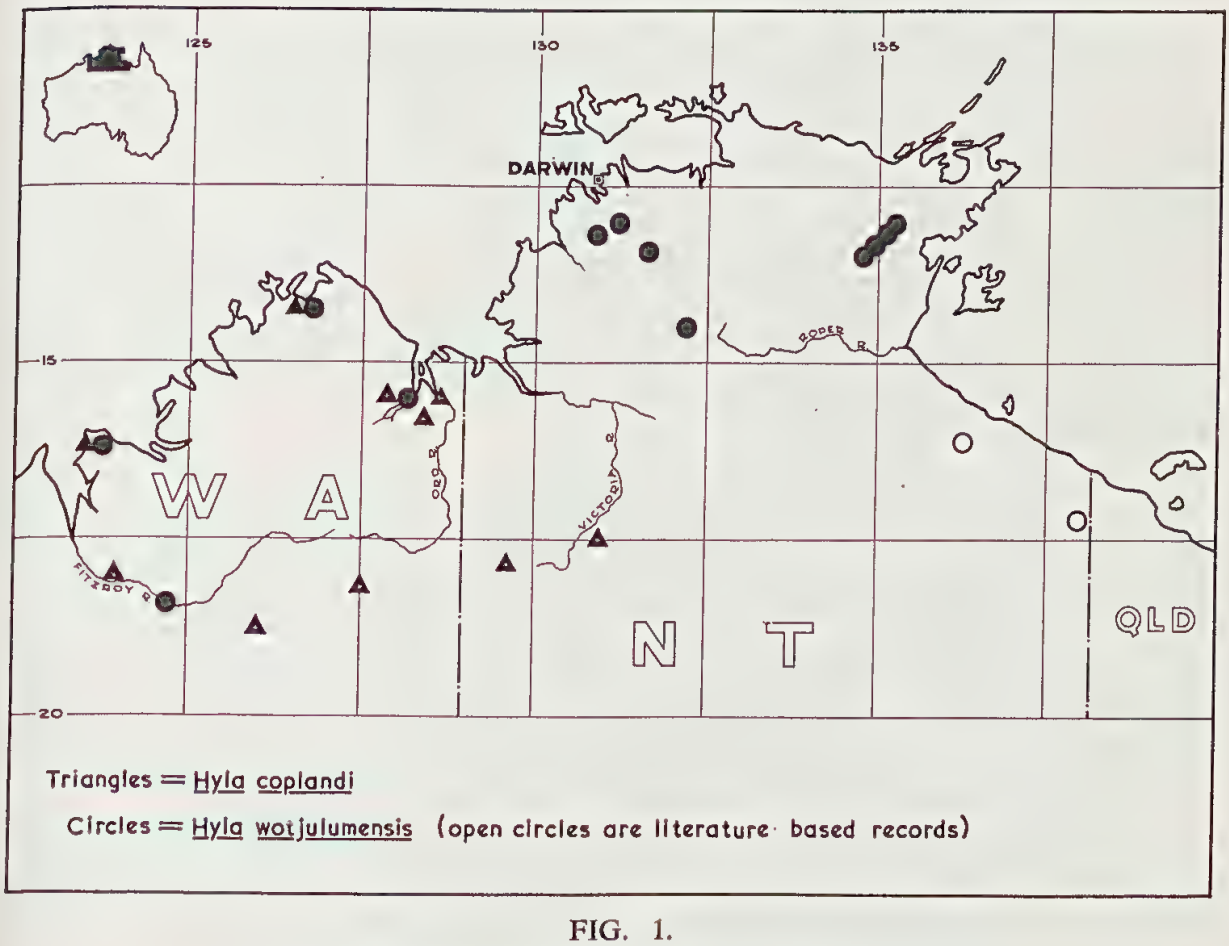


FIG. 1.
Distribution of *Hyla coplandi* and *H. wotjulumensis*.

In the absence of any geographical or environmental barrier the extension of its distribution eastwards into Queensland seems likely. The only literature based locality records included in the distribution map (Fig. 1) are those cited by Hosmer (1964) for *spaldingi* specimens examined by that author.

Hyla coplandi new species

Hyla latopalmata watjulumensis (part) Copland (1957), Proc. Linn. Soc. N.S.W., **82** (1), p. 96.

Holotype: W.A.M. R.13722G. A gravid female collected at Inverway Station, Northern Territory by K. G. Buller on 8 August, 1960.

Definition: A moderately sized species with a maximum snout to vent length of 41.8 mm., characterized by the combination of the following features: unwebbed fingers, fully webbed toes, dilated terminal digital discs, apposable first finger, large tympanum and a prominent gland at the angles of the jaws.

Description of Holotype: The head is longer than broad (HL/HW 1.054), its length equivalent to considerably more than one-third of the snout to vent length (HL/S-V 0.402). The snout projects only slightly; it is rounded when viewed from above and evenly rounded in profile. The nares are high and oblique, their distance from the end of the snout less than that from the eye. The distance between the eye and the naris is slightly greater than the internarial span (E-N/IN 1.053). The canthus rostralis is very poorly defined and straight. The loreal region is slightly concave. The eye is not prominent, its diameter equal to the eye to naris distance. The tympanum is prominent, its diameter equivalent to almost seven-eighths of the eye diameter, and separated from the eye by a distance equivalent to one-third of its own diameter. The vomerine teeth are situated on each side of the midline on two rounded elevations on a ridge overhanging the anterior margins of the choanae. The tongue is broadly cordiform with a feeble posterior indentation.

The fingers are long and slender with narrow lateral fringes and very large sub-articular tubercles. In decreasing order of length $3 > 4 > 1 > 2$. There is no inter-digital webbing. The terminal discs are dilated (Fig. 2).

The hindlimbs are long and slender with a TL/S-V ratio of .601. Toes in decreasing order of length $4 > 5 = 3 > 2 > 1$. The interdigital webbing reaches the base of the terminal discs of all toes except the fourth where it extends as far as the sub-articular tubercle at the base of the penultimate phalanx, and is united to the disc by a narrow lateral fringe (Fig. 2).

There are numerous small, rounded granules on the entire dorsal surface of the head and body. At the angle of the jaws is a small but prominent, roughly circular gland composed of a group of large granules, and the sides of the body are covered with granules, more numerous than on the dorsum.

There is a very poorly developed supra-tympanic fold, a skin fold on the outer edge of the forearm, a sharp fold on the outer surface of the tarsus and a fold across the chest. There is an extremely prominent oval outer metatarsal tubercle. Supernumerary tubercles on the foot are well developed. The throat is smooth but for a few very small isolated granules, and the abdomen and posterior thighs very coarsely granular.

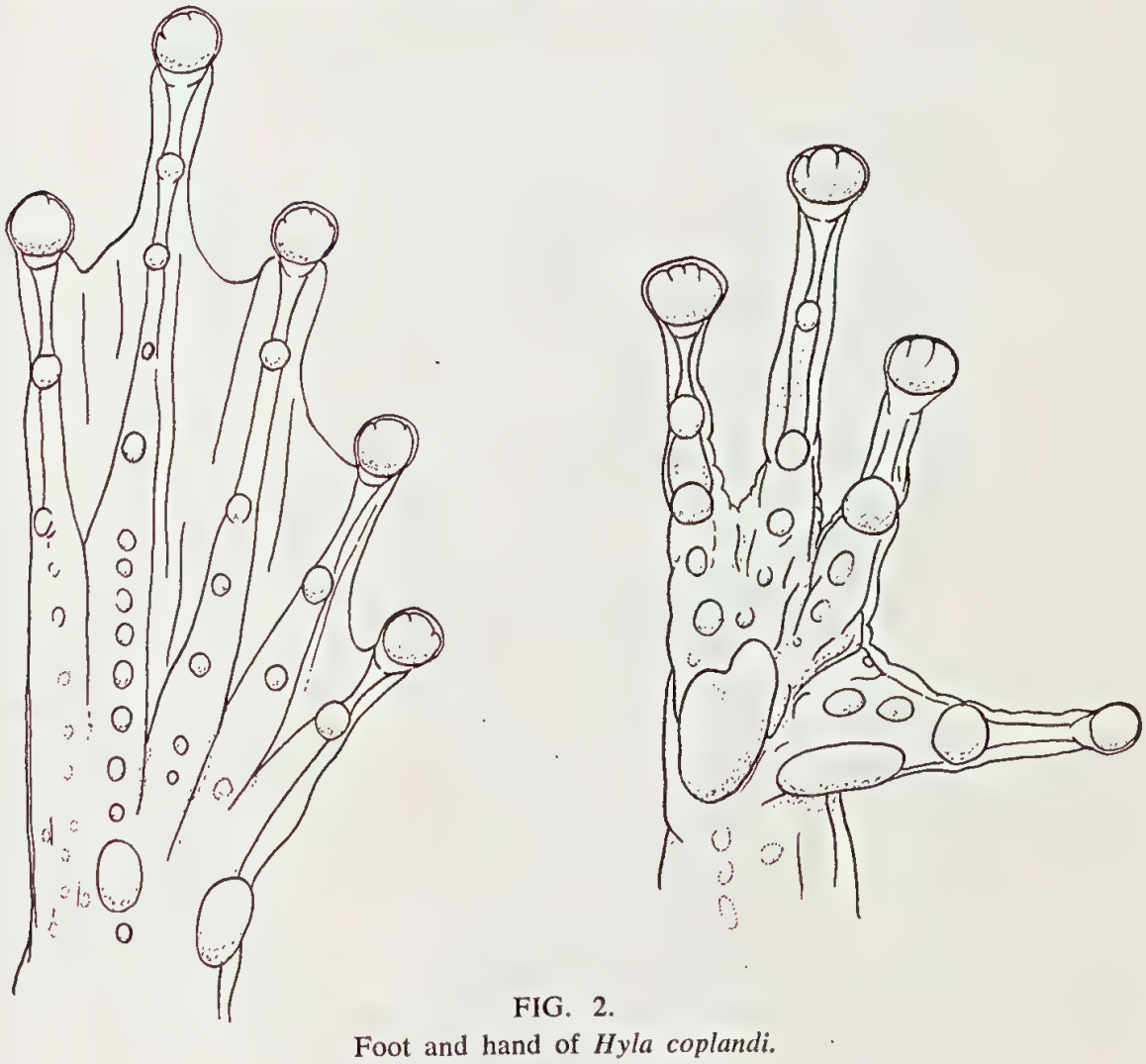


FIG. 2.
Foot and hand of *Hyla coplandi.*

Dimensions: Snout to vent length 38.8 mm.; tibia length 23.3 mm.; head length 15.6 mm.; head width 14.8 mm.; eye to naris distance 4 mm.; internarial span 3.8 mm.; eye diameter 4 mm.; tympanum diameter 3.4 mm.

In preservative the dorsal surface of the body and limbs is a dull brown with extremely obscure and irregular darker markings. The posterior surface of the thighs is a very dark brown bearing small creamish patches. The gland at the angle of the jaws and most of the granules on the sides of the body are dull yellow. The undersurface of the tarsus and foot are charcoal grey.

Variation: There are eight paratypes: W.A.M. 13722E-F collected with the holotype at Inverway Station and W.A.M. 13724A-D, 13724I, S.A.M. R.9103 (formerly W.A.M. R.13722D) collected at Wave Hill, Northern Territory by K. G. Buller on 11 August, 1960. Males in the paratype series bearing nuptial pads have snout to vent lengths of 33.5-34.7 mm., and the females are 37.3-40.2 mm. In their proportions and coloration they do not differ markedly from the features of the holotype (see Table 1 for measurements and ratios of types and topotypes).

A further 47 representatives of this species have been examined:

Northern Territory—
Inverway Station—W.A.M. R.13722A-C.
Wave Hill—W.A.M. R.13724E-H.

Western Australia—
Bugle Gap—W.A.M. R.21354-8, 26235-7.
Kalumburu—W.A.M. R.13762, 13764A-B, 13775B, 29547, 29550-1.
Kununurra—S.A.M. R.5083.
Moolabulla—S.A.M. R.5537.
Mt. Anderson—W.A.M. R.29558-60.
Parry Creek—W.A.M. R.29570-2.
Wotjulum—W.A.M. R.11197, 11939, 11638 (syntypes of *latopalmata watjulumensis*).
23m. S.S.E. of Wyndham—W.A.M. R.26122-3, 26125, 26127, 26134.

The smallest male bearing nuptial pads (W.A.M. R.21357) has a snout to vent length of 31.2 mm. A gravid female (S.A.M. R.5083) is the largest examined, measuring 41.8 mm. A specimen from Parry Creek (W.A.M. R.29571) is depicted in Fig. 5.

Comparison with Other Species: *Hyla coplandi* differs from all other species of the *lesueuri* complex occurring in north-western Australia in lacking anterior and posterior lateral head markings. *Hyla wotjulumensis* is the only species sharing with *coplandi* fully webbed toes but, in addition to possession of broad, and usually particularly conspicuous head stripes, *wotjulumensis* has a more elongated snout and a correspondingly longer head than *coplandi*, as indicated by comparison of the HL/HW ratios (1.056-1.260 in *wotjulumensis* and 0.985-1.063 in *coplandi*). In *Hyla coplandi* the terminal digital discs are strongly dilated and usually approximately twice the width of the penultimate phalanges, whereas in *wotjulumensis* the discs are only slightly broader than them. The latter feature also distinguishes *latopalmata* and *nasuta* from *coplandi*. These three species may also be distinguished by differences in HW/S-V proportions (Fig. 3).

Of the species confined to eastern Australia, *Hyla booroolongensis* shares with *coplandi* similarly extensive webbing between the toes and dilated terminal discs. The former species differs from *coplandi* in the following respects: The first finger is shorter than (not longer than) the second; the head is consistently broader than long (longer than broad in 55 of 56 *coplandi*); the vomerine teeth are set more posteriorly in relation to the position of the choanae, there is no gland at the angle of the jaws and the outer metatarsal and supernumerary tubercles are not as well developed. *Hyla booroolongensis* evidently attains a larger size than *coplandi*, for the maximum snout to vent length recorded by Moore (1961) was 50.5 mm., whereas the largest *coplandi* measures 41.8 mm.

Distribution: The known geographic range of *coplandi* extends as far south as the Fitzroy River in Western Australia, and east to Wave Hill near the source of the Victoria River in the Northern Territory (Fig. 1). The eight Western Australian localities at which it has been collected lie in a circle, which may be more of an indication of the accessibility of certain localities than a true representation of the distribution of the species. No specimens of *coplandi* have been included in several large collections examined from the northern portion of the Northern Territory; much of this material was from Arnhem Land.

Hyla latopalmata (Gunther)

Pelodytes affinis Gray (1842), Zool. Misc. p. 56.

Hyla affinis, Boulenger (1882), p. 413; Andersson (1913), p. 24.

Litoria latopalmata Gunther (1867), Ann. Mag. nat. Hist. Ser. 3, Vol. 20, p. 55.

Hyla latopalmata, Boulenger (1882), p. 414; Loveridge (1935), p. 52; Moore (1961), p. 298.

Hyla tornieri Nieden (1923), Das Tierreich No. 46, p. 228.

Hyla lesueurii, Mitchell (1955), p. 404; Copland (1957) (part), p. 89; Mitchell (1964), p. 339.

Hyla latopalmata latopalmata, Copland (1957), p. 94.

This species either exhibits greater morphological variation than any other member of the complex or comprises two populations meriting distinct taxonomic recognition. Evidence obtained in the present studies favours the former hypothesis but the latter cannot be completely excluded. However, it is considered that biological data are more likely to establish the matter and at the present time none are available.

The geographic range of *latopalmata* extends in the form of a continuous arc from New South Wales to Western Australia—a distance of approximately 3,000 miles. Comparison of adult specimens from Western Australia (previously reported as *Hyla affinis* by Andersson, 1913) with

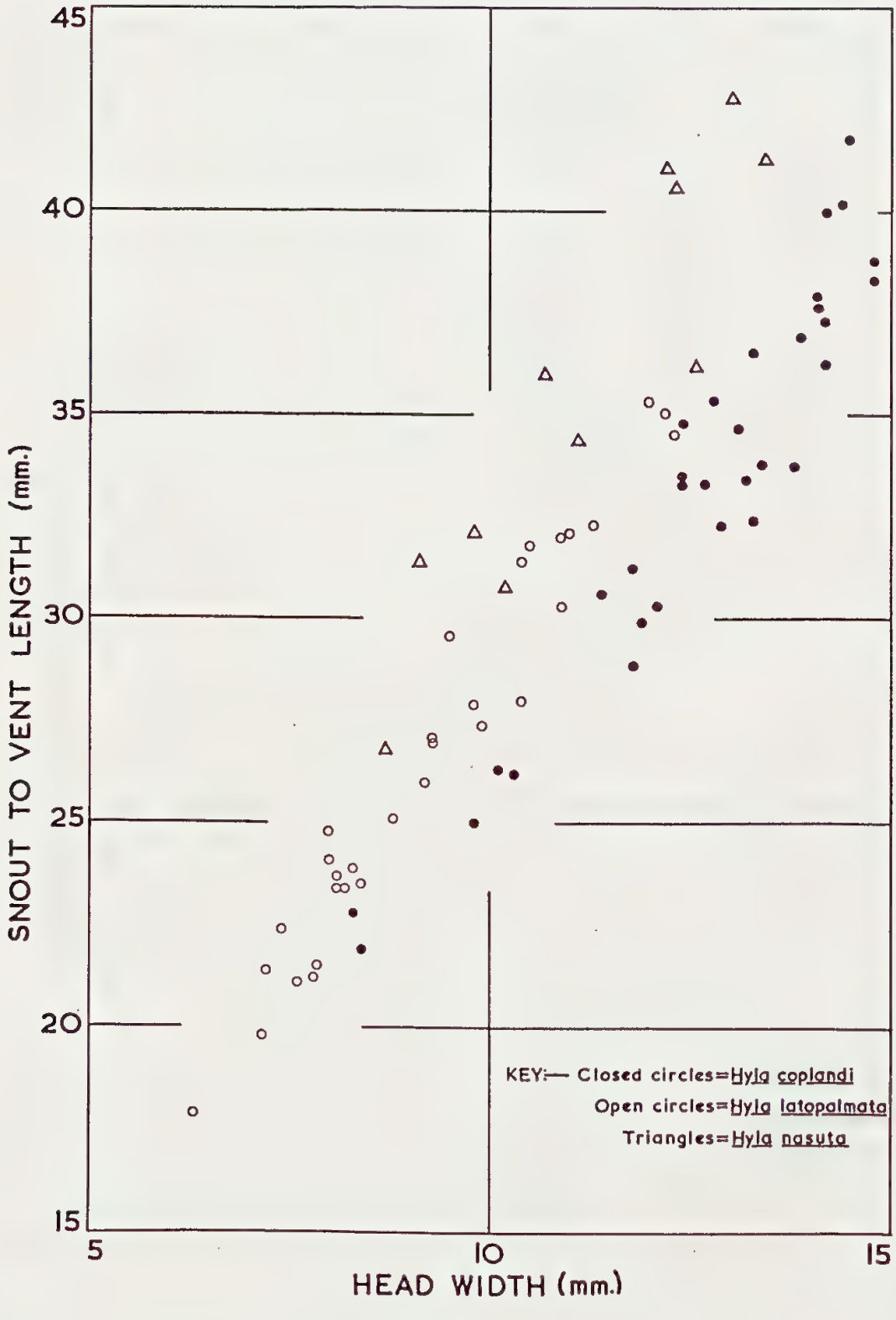


FIG. 3.
Head width/snout-vent length in three species of *Hyla*.

adults from southern Queensland and New South Wales reveals striking differences (see Table 2 for a comparison of measurements). The Western Australian frogs are smaller than those from the eastern States, have shorter limbs and are always dull brownish dorsally (never the dull grey common to most preserved eastern specimens). The lateral head stripes are only slightly darker than the background coloration whereas in eastern frogs they are black and extremely conspicuous. The terminal digital discs of Western Australian frogs are always undilated and no broader than the width of the penultimate phalanx, whereas eastern individuals invariably exhibit dorso-ventral flattening and, in those instances where they are distinctly broader than the penultimate phalanges, a circum-marginal groove is detectable.

There are further minor points of divergence in the extent of interdigital webbing and development of supernumerary tubercles on the plantar surface.

As indicated by the data presented in Table 2, at intermediate localities there is a wide range of variation in the proportions of individuals. Of the characters considered above the only consistent geographic trends noted involve terminal digits and interdigital webbing. Dilation with or without lateral expansion beyond the penultimate phalanges has not been observed in any frogs collected north or west of central Queensland, and the webbing is definitely most extensive in frogs from southern Queensland and New South Wales. Frogs with dilated and undilated terminal phalanges evidently occur in the latter area as evidenced by comparison of Moore's (1961) line figure of the hand, with the hand of the individual illustrated in his plate 45.

TABLE 2

Proportions of *Hyla latopalmata*

	F	TL/S-V	E-N/IN	HL/HW	Adult Size (S-V in mm.)	
					♂♂	♀♀
Port Essington, N.T. (*affinis* holotype) ...	1	.547	1.167	1.025	34.3	—
Bowen, Qsld. (*latopalmata* syntype)	1	.614	1.072	1.045	—	36.3
Vicinity of Fitzroy River, W.A.	5	.518-.548 (.532)	.936-1.000 (.978)	1.062-1.091 (1.077)	—	32.1-36.3
Kununurra, W.A. ...	8	.531-.571 (.545)	.921-1.095 (.997)	1.173-1.311 (1.222)	—	—
Mornington Island, Qsld.	46	.606-.673 (.633)	.906- .971 (.951)	1.131-1.262 (1.189)	—	—
Bullman Waterhole, N.T.	11	.604-.686 (.644)	.897-1.000 (.950)	1.074-1.271 (1.168)	—	—
Doomadgee Station, Qsld.	2	.610 (.610)	.920- .964 (.942)	1.139-1.189 (1.164)	—	—
South Queensland and N.S.W.	7	.585-.664 (.632)	.892-1.107 (1.038)	1.054-1.124 (1.078)	31.9-32.8	37.3-42.4
73m. N. of Mainoru, N.T.	8	.574-.617 (.597)	.920-1.087 (1.019)	1.083-1.205 (1.137)	—	—

Material Examined: 139 specimens:—

Western Australia—

Kununurra—S.A.M. R.5827 (9).
Noonkanbah—N.R. 1578.
Parry Creek—W.A.M. R.29567, 29569.
St. George Range—N.R. 1579-80; M.C.Z. 18000.
23m. S.S.E. of Wyndham—W.A.M. R.26124, 26126, 26128-33, 26135.
Yeeda—N.R. 1577.

Northern Territory—

7m. S. of Adelaide River—W.A.M. R.26249-50.
Berry Springs, 15m. S.S.E. of Darwin—S.A.M. R.8983-5.
Bulman Waterhole—S.A.M. R.8174 (11).
Coomalie Creek—W.A.M. R.26244.
Ingaladdie Waterhole—S.A.M. R.8174 (11).
Katherine—W.A.M. R.13951, 26141-4.
Katherine Gorge—S.A.M. R.4874 (7).
Koolpinyah Stn.—A.M.N.H. 43835.
78m. N. of Mainoru—S.A.M. R.9064-71.
83m. N. of Mainoru—S.A.M. R.9062-3
98m. N. of Mainoru—S.A.M. R.9072-3.
90m. N. of Mainoru—S.A.M. R.9105.
Mt. Bundy Stn.—S.A.M. R.4878 (2).
Newcastle Waters—S.A.M. R.4873 (2).
Oenpelli—U.S.N.M. 128719.
?Port Essington—B.M. 1947.2.22.73 (holotype of *Pelodytes affinis*).
Wilton River Crossing, 68m. N. of Mainoru—S.A.M. R.9135(6).

Queensland—

Brisbane—S.A.M. R.3643, 6321 (2).
Doomadgee Stn.—S.A.M. R.5013 (2).
Mornington Is.—S.A.M. R.4935 (46).
St. George—S.A.M. R.3692, 3737.
Woodridge—S.A.M. R.3648.

New South Wales—

Darling River—S.A.M. R.5470 (3).
Macquarie River—S.A.M. R.5464 (3).

Distribution: On the distribution map of Moore (1961) there are very few records from Western Australia and the Northern Territory, and there is a wide gap between the most eastern Northern Territory record and the east coast of Queensland. Figure 4 provides a more detailed picture of the distribution of the species in the northern portion of the continent.

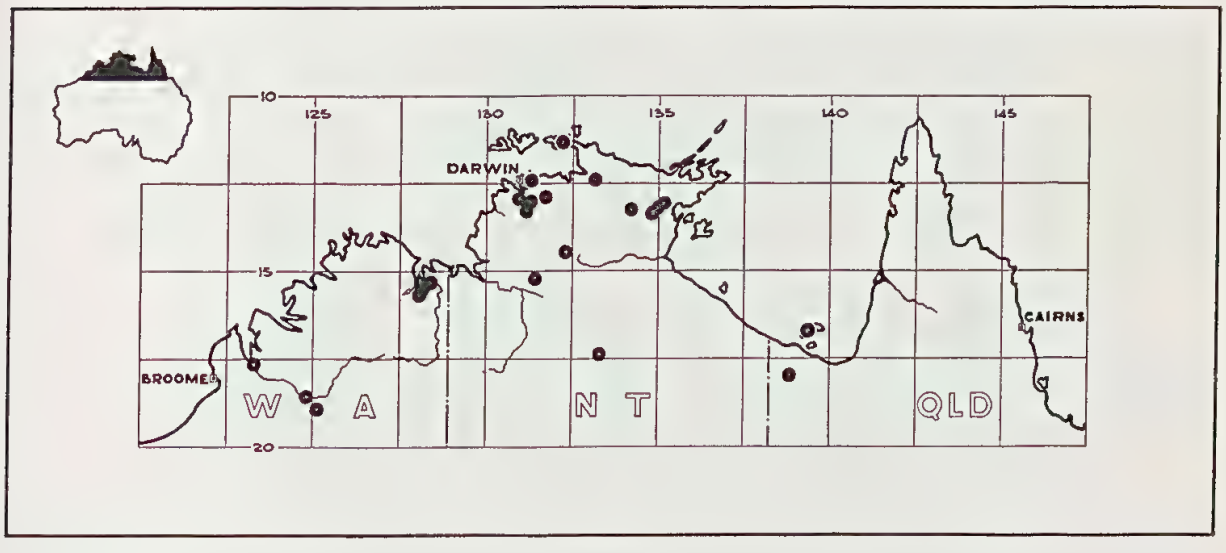


FIG. 4.
Distribution of *Hyla latopalmata* in Northern Australia.

Hyla nasuta (Gray)

Pelodytes nasutus Gray (1842), Zool. Misc., p. 56.

Hyla nasuta, Fry (1914), p. 210; Mitchell (1955), p. 405; Copland (1957), p. 100; Moore (1961), p. 305; Mitchell (1964), p. 340.

In view of the extensive literature on this species comments are confined here to details of the specimens on which the data in Table 1 are based, a comparison with other members of the *lesueuri* complex occurring in north-western Australia and details of distribution.

Material Examined: 13 specimens:—

Western Australia—
Kalumburu—W.A.M. R.13752A-C, 13777, 29541-2.
Kununurra—S.A.M. R.5082 (2).

Northern Territory—
7m. S. of Adelaide River—W.A.M. R.26248.
Cape Don—W.A.M. R.26680.
Coomalie Creek (16m. N. of Adelaide River)—W.A.M. R.26243.
Groote Eylandt—S.A.M. R.3253 (2).

Comparison with Other Species: Pronounced elongation of the head producing a very high HL/HW ratio (Table 1), the extreme reduction of webbing between the toes and the presence of longitudinal skin folds and stripes on the body, are a combination of features not shared by any other member of the complex occurring in Western Australia and the Northern Territory.

Distribution: The only specimens of *nasuta* previously collected in Western Australia are three from Napier Broome Bay reported by Fry (1914). One of these was seen by Moore (1961) and the locality was represented on his distribution map. Kalumburu is situated on Napier Broome Bay and the only further Western Australian specimens known to be in existence are those from Kununurra on the Ord River near the State boundary.

Hyla nigrofrenata Gunther

Hyla nigrofrenata Gunther (1867), Ann. Mag. nat. Hist., Ser. 3, Vol. 20, p. 56; Boulenger (1882), p. 413; Moore (1961), p. 312.

Moore (1961) examined the syntypes of *nigrofrenata* and resurrected the species from the synonymy of *lesueuri* to which it had been referred by Loveridge (1935). One of these syntypes (B.M. 1947.2.23.46) and other material reported in the literature as *nigrofrenata* have been re-examined, and the conclusion reached that no specimens clearly conspecific with the types have been subsequently examined. It is possible that the species will ultimately prove to have a limited geographic range within Queensland.

This species can be distinguished from those occurring in the Northern Territory and Western Australia as follows:

The webbing on the foot of *nigrofrenata* extends midway up the penultimate phalanx on the fifth toe. This feature distinguishes the species from *coplandi* and *wotjulmensis* where the webbing reaches the base of the disc. The presence of lateral head stripes distinguishes *nigrofrenata* from *coplandi* and its form (disrupted behind the eye) is unlike that of *nasuta* and *wotjulumensis*. Although *latopalmata* shares a disrupted posterior head stripe, in *nigrofrenata* the posterior portion is as broad as the portion immediately behind the eye (as depicted in the illustration of Boulenger, 1882) wheras in *latopalmata* it is very much narrower. None of the 139 specimens of *latopalmata* examined bear the slightest resemblance to *nigrofrenata* in this respect.

Hyla nigrofrenata is evidently a larger species than *latopalmata*, for the syntype is an adult male with a snout to vent length of 42.3 mm. This is as large as the largest female *latopalmata* examined by the writer (42.4 mm.) and Moore (1961) (42.5 mm.).

FIG. 5.
Hyla coplandi.

KEY TO THE *HYLA LESUEURI* COMPLEX OF WESTERN AUSTRALIA AND THE NORTHERN TERRITORY

1. Webbing reaches base of terminal disc on fifth toe 2
   Webbing does not extend beyond a point approximately midway up penultimate phalanx on fifth toe 3

2. Finger and toe discs distinctly dilated and approximately twice the breadth of penultimate phalanges; lateral head stripe absent; S-V length of gravid females less than 45 mm. *Hyla coplandi*

Finger and toe discs slightly dilated and scarcely broader than penultimate phalanges; broad lateral head stripes present; S-V length of gravid females greater than 45 mm. . . . . *Hyla wotjulumensis*

3. Disc and two phalanges of fourth toe free from web; head markedly elongate with HL/HW ratio exceeding 1.275; broad continuous longitudinal stripes and narrow skin folds on body . . . . . *Hyla nasuta*

Disc and no more than penultimate phalanx of fourth toe free from web; head, if elongate, with HL/HW ratio less than 1.275; neither longitudinal stripes nor skin folds on body . . *Hyla latopalmata*

SUMMARY

Four species of the *Hyla lesueuri* complex are reported from Western Australia and the Northern Territory: *Hyla coplandi* new species, *H. latopalmata, H. nasuta* and *H. wotjulumensis.* The morphological variation of each species is discussed and tabulated and distribution data presented. *Hyla nigrofrenata* is compared with these species and excluded from the Northern Territory fauna.

The following nomenclatural changes are proposed:
Hyla latopalmata watjulumensis Copland = *Hyla wotjulumensis* Copland.
Hyla spaldingi Hosmer = *Hyla wotjulumensis* Copland.

ACKNOWLEDGMENTS

I wish to record my sincere thanks to Dr. G. Storr of the Western Australian Museum for making a large number of specimens available to me and for answering numerous queries about them. Additional material was provided on loan by Miss A. G. C. Grandison (British Museum, Natural History), Dr. J. A. Peters (United States National Museum), Dr. G. Vestergren (Naturhistoriska Riksmuseet), Dr. E. E. Williams (Museum of Comparative Zoology), and Dr. R. G. Zweifel (American Museum of Natural History). Mr. H. G. Cogger kindly permitted me to examine specimens at the Australian Museum. I am greatly indebted to Mr. W. Harrington for preparation of Figs. 1, 3 and 4 and to Mr. R. Ruehle for the photographic plate.

My thanks are also due to the Director and Board of the South Australian Museum for the provision of laboratory facilities and other forms of assistance, and to Mr. F. J. Mitchell for his constructive criticism of the manuscript.

REFERENCES

Andersson, L. G., 1913: Results of Dr. E. Mjöberg's Swedish Scientific Expeditions to Australia 1910-1913. Amphibia. *Svenska Vetensk.—Akad. Handl.,* 52 (4): 1-26.

Boulenger, G. A., 1882: Catalogue of the Batrachia Salientia s. Ecaudata in the collection of the British Museum. 2nd Ed., British Museum, London, 503 pp.

Copland, S. J., 1957: Australian tree-frogs of the genus *Hyla. Proc. Linn. Soc. N.S.W.,* 82 (1): 9-108.

Fry, D. B., 1914: On a collection of reptiles and batrachians from Western Australia. *Rec. W. Aust. Mus.*, 1 (3): 174-210.

Glauert, L., 1959: Herpetological Miscellanea 9. *Ablepharus wotjulum*, a new skink from West Kimberley. *W. Aust. Nat.*, 6 (8): 192-3.

Hosmer, W., 1964: A new frog of the genus *Hyla* from Northern Territory, Australia. *Amer. Mus. Novi.* (2182): 1-7.

Kinghorn, J. R., 1931: Herpetological notes No. 2. *Rec. Aust. Mus.*, 18: 85-91.

Loveridge, A., 1935: Australian amphibia in the Museum of Comparative Zoölogy, Cambridge, Massachusetts. *Bull. Mus. comp. Zool.*, 78 (1): 1-60.

Mitchell, F. J., 1955: Preliminary account of the reptilia and amphibia collected by the National Geographical Society-Commonwealth Government-Smithsonian Expedition to Arnhem Land (April to November, 1948). *Rec. S. Aust. Mus.*, 11 (4): 373-408.

———— 1964: Reptiles and Amphibians of Arnhem Land. In: *Records of the American-Australian Scientific Expedition to Arnhem Land*, Vol. 4, Zoology, Ed. R. L. Specht, Melbourne Univ. Press, pp. 309-343.

Moore, J. A., 1961: The frogs of eastern New South Wales. *Bull Amer. Mus. Nat. Hist.*, 121 (3): 149-386.

Tyler, M. J., 1968: Papuan hylid frogs of the genus *Hyla*. Zool. Verh., 96: 1-203.

THE SHALLOW WATER ECHINODERM FAUNA OF SOUTH AUSTRALIA

Part I: The Asteroids

By SCORESBY A. SHEPHERD, c/o South Australian Museum

INTRODUCTION

At the time of the paper by Cotton and Godfrey (1942) and the monograph of H. L. Clark (1946) observation of the habits of seastars was limited to intertidal species.

Scuba equipment now permits direct observation to a depth of about 60 m.

Since 1958 the author has been engaged in underwater surveys of South Australian coastal waters and the observations recorded in this paper are a result of these efforts.

Simplified descriptions and keys are given to assist the field collector in the identification of the 31 species occurring down to 60 m. As man's range is continually being extended into even deeper water all species so far recorded from the Continental shelf of southern Australia are listed in Table 6.

In the formal parts of the text the ordinal classification adopted by Fisher (1930) as modified by Fell (1963 and 1966) is used. Where necessary the status of a species is discussed but otherwise only synonyms and references later than Clark's work (1946) are given.

Finally, biogeographic notes are made, and a summary is given (Table 5) of the species according to habitat.

The following abbreviations are used:—A.M., Australian Museum; N.M.V., National Museum of Victoria; T.M., Tasmanian Museum; S.A.M., South Australian Museum; and W.A.M., Western Australian Museum.

KEY TO THE ASTEROID GENERA OF THE CENTRAL FLINDERSIAN REGION

1. Arms long tapering and strap-like, flattened above and below; tube feet pointed without sucking disk 2

   Not as above; arms not flattened. Tube feet with sucking disk 3

2.	Arms 7	*Luidia australiae*
	Arms 5	*Astropecten* spp.
3.	The margin thick or rounded, formed by marginal plates usually prominent. Dorsal skeleton of paxilliform plates or with tubercles or flat tesselate plates . .	4
	Marginal plates usually not large and conspicuous; dorsal skeleton not composed of true paxilliform plates and not in form of pavement, more usually imbricated or reticulated	9
4.	Dorsal, marginal, and ventral plates covered and obscured by a smooth skin	*Petricia vernicina*
	Plates not covered by a smooth skin	5
5.	Marginal plates large and few, not more than 20 across an interbrachial arc; dorsal plates smooth	6
	Marginal plates very numerous, more than 20 across an interbrachial arc; dorsal plates paxilliform with extensive granulation, or with tubercles	7
6.	Interbrachial arcs usually fairly deep. Colour bright yellow to orange	*Pentagonaster duebeni*
	Body pentagonal or nearly so. Colour brown, dull red	*Tosia* spp.
7.	Dorsal plates paxilliform, without tubercles and covered with layer of granules. Pedicellariae inconspicuous	*Nectria* spp.
	Dorsal plates bear numerous large tubercles (one to a plate)	8
8.	Tubercles conically pointed. Large valvate pedicellariae	*Anthaster valvulatus*
	Tubercules large and rounded pedicellariae inconspicuous	*Asterodiscus truncatus*
9.	Arms webbed; margin thin	10
	Arms distinct; almost round in cross-section; not webbed	12

10.	Dorsal plates of about the same size, round and with very fine peripheral spinelets . .	*Asterina atyphoida*
	Dorsal plates of two sizes, primary ones crescentic; spinelets or granules cover their surface	11
11.	Ventral plates each have a cluster of fine spinelets	*Paranepanthia grandis*
	Ventral spines coarse and only one or two to a plate	*Patiriella* spp.
12.	Dorsal and ventral plates covered with minute granules or spinelets	13
	Dorsal plates form an open network bearing isolated or irregular spines, spinelets or granules (not forming a continuous coat)	14
13.	Yellow in life, papulae appear as black dots	*Austrofromia polypora*
	White or nearly so, or faintly pink	*Nepanthia troughtoni*
14.	Two series of tube-feet along each furrow . .	15
	Four series of tube-feet along each furrow .	16
15.	Dorsal plates form a coarse network with large meshes	*Plectaster decanus*
	Dorsal plates form an indistinct network, the meshes bearing small pointed spines singly or in clusters	*Echinaster* spp.
16.	Arms 6 to 14 often unequal in size through regeneration	17
	Arms 5	18
17.	Dorsal spines prominent and isolated, surrounded by wreath of fine crossed pedicellariae; arms 7-14	*Coscinasterias calamaria*
	No prominent isolated spines; dorsal plates and spinelets form a regular longitudinal series; arms 6 to 9 usually 8	*Allostichaster polyplax*
18.	Dorsal skeleton forms a network with coarse blunt spines. Ventral spines chisel-like. R up to 80 mm.	*Uniophora* spp.
	Dorsal plates bearing fine spinelets. R is less than 45 mm.	19
19.	Colour dull brown	*Allostichaster regularis*
	Colour mottled dark and light red	*Smilasterias irregularis*

Class STELLEROIDEA
Subclass ASTEROIDEA
Order PLATYASTERIDA
Family LUIDIIDAE
Genus LUIDIA Forbs

Luidia (Maculaster) australiae Döderlein

Luidia australiae Döderlein (1920), p. 266.

Maculaster australiae Fell H. B. (1963), pp. 433-4.

Description: Arms 7 in number, long tapering and strap-like, flattened above and below. Arms and disk dorsally covered with squarish or polygonal paxilliform plates covered with minute granules. Photographed in Dakin (1960) Plate 82. Maximum R. is 200 mm.

Remarks: In his monograph on the phylogeny of seastars Fell (1963) removed the Family Luidiidae from the order Phanerozonia to an earlier phylogenetic order Platyasterida; he also divided the genus *Luidia* into 9 genera and referred the species *australiae* to a new genus *Maculaster*. In view of Fell's uncertainty as to whether his new divisions should warrant any higher status than that of sub-genera, I adopt a trinomial classification.

This *Luidia* is usually seen at depths of 15 m. or more upon a fine sand or silt bottom where the angiosperm *Halophila ovalis* is often dominant. Thus it is common in the deeper parts of Spencer and St. Vincent Gulfs. Its diet includes molluscs and ophiuroids and it frequently buries itself in the sand by lateral arm movements, probably in search of its prey. A specimen taken 2-3 miles off Pt. Noarlunga, St. Vincent Gulf at 20 m. contained remains of the ophiuroid *Ophiomusium* sp.

On exposure to air the animal autotomizes readily. The range of the species is from Fremantle, Western Australia to Moreton Bay, Queensland.

Order PHANEROZONIA
Family ASTROPECTINIDAE
Genus ASTROPECTEN

This complex cosmopolitan genus is represented in South Australian seas by three or possibly four species. The following key and figure are offered to distinguish the species. A photograph of *Astropecten pectinatus* appears in Dakin (1960), Plate 81.

Description: Five tapering arms, flattened above and below. Dorsal surface covered with tightly packed elevated paxilliform plates each bearing a cluster of small spinelets. Marginal plates conspicuous and form outline of arms. Infero-marginal plates with long spines.

Key to Species:

1. 20-40 ventro-lateral plates in each intermediate area . . . . . *pectinatus*
   Single series only of ventro-lateral plates comprising 2 or 3 plates 2
2. Supero-marginal plates without spines . . . . . *preissi*
   Supero-marginal plates with spines 3
3. Usually 1 or 2 (sometimes 3) supero-marginal spines to a plate . . . . . *vappa*
   Occasionally 1 or 2, usually 3, sometimes 4 supero-marginal spines to a plate . . . . . *triseriatus*

Astropecten pectinatus Sladen

Fig. 1 d, e

Astropecten pectinatus Sladen (1883), p. 251; D. D. John (1948), p. 497; A. M. Clark (1962), p. 98.

Astropecten schayeri Döderlein (1917), p. 60.

Astropecten syntomus H. L. Clark (1928), p. 372.

A consequence of Sladen's failure (1883 p. 251) to see all the ventro-lateral plates in the intermediate areas in *Astropecten pectinatus* was the description of a new species *A. schayeri* from Tasmania by Döderlein. Clark (1938 at p. 66) reiterated the differences between the two species noting that *A. schayeri* had a greater number of ventro-lateral plates, longer spines on the infero-marginal plates and a greater number of adambulacral spines. John (1948 p. 497) detected Sladen's omission and discounted the remaining differences.

Examination of specimens from southern Australia and comparison of them with the specimen of *A. schayeri* in the N.M.V. which H. L. Clark (1938) examined and stated was very similar to Döderlein's type shows that the character differences are subspecific. I find in general that the specimens from Victoria and Tasmania tend to have coarser granules on the dorsal paxillae, longer and coarser spinelets on the infero-marginal plates, a greater number of prominent spines on the infero-marginals (see Fig. 1) and coarser adambulacral spines; these differences may be attributable in part but not wholly to the larger size of these specimens. Other differences are tabulated in Table 1. John (l.c.) was probably correct when he inferred that Döderlein (1917) in stating that the adambulacral armature of *A. schayeri* contained up to 17 spines, included in his count the spines on the intermediate plates. In the specimen of *A. schayeri* from N.M.V. referred to above, the adambulacral armature comprises up to 14 spines but

immediately behind on the intermediate plate there are 3 or sometimes 4 spines very similar in shape and size giving the appearance of a dense group of spines numbering up to 17. The spines on the intermediate plates of specimens from New South Wales and Western Australia are smaller and finer, and hence it is not difficult to distinguish them from the adambulacrals.

The specimens from Port Arthur Bay, Tasmania are of exceptional interest as they indicate that *A. pectinatus* may have an additional row of 1 to 4 large spines on the proximal infero-marginal plates. (See Fig. 1.) Thus it is evident that *A. syntomus* is within the variation of *A. pectinatus* and must be referred to that species. I am not able to find any significant differences between the specimens from New South Wales and those from Western Australia.

On the New South Wales coast the habitat of *A. pectinatus* is fine sand or sandy mud: in Bass Strait it is recorded on sand and shelly bottom and in Port Arthur Bay, Southern Tasmania on sandy mud. In South Australia the species is rare; it has been taken at 30 m. near St. Francis Island, Great Australian Bight and has been dredged by Verco, presumably in St. Vincent or Spencer Gulf. The colour of New South Wales specimens is recorded as a fleshy pink. The species ranges from 30-280 m. and has a southerly distribution around Australia between Rottnest, Western Australia and Newcastle, New South Wales.

TABLE I

The variation in *Astropecten pectinatus*

Material	Range in R in mm. Range in R/r Mean R/r	Armature of Supero-marginal Plates	Range in Number of Ventrolateral Plates	Range in Number of Large Infero-marginal Spines	Number of Spines Comprising Adambu-lacral Armature
10 specimens from off Rottnest, W.A. at 160m.	30-40 3.4-4.0 3.7	Most plates carry 1 small spine, rarely larger than 1 mm.	17-29	3-5	9-12
7 specimens from Bass Strait and southern Tasmania at 30m.	48-60 3.3-3.8 3.6	All plates with 1 (occasionally 2) spines. At arm angle may be up to 3mm. long	20-36	4-9	9-14
5 specimens off Cronulla and Newcastle N.S.W. at 80-280m.	29-49 3.2-3.8 3.5	Most plates with 1 spine up to 1.5mm. long	21-29	3-5	8-11
Type specimen of *A. syntomus*	41 3.0	Most plates without spines	50	4-8	9

Astropecten preissi Müller and Troschel

Fig. 1 b

Astropecten preissi Müller and Troschel (1843), p. 119.

There is some variation in the number of prominent spines of the infero-marginal plates; Fig. 1 shows the armature of a typical South

Australian specimen. Some specimens from Shark Bay have up to 3 or 4 fewer such spines.

This *Astropecten* is a common seastar of deeper water between 15 and 30 m. in St. Vincent Gulf where it is found on a bottom of fine silty calcareous sand. It is common 2 or 3 miles off Port Noarlunga, St. Vincent Gulf.

The species is known to feed on small bivalves and probably ingests other sand-dwelling animals as well. The feeding habits of a congener from the South Carolina coast U.S.A. has recently been studied by Wells and others (1961). The species ranges from Shark Bay, Western Australia to St. Vincent Gulf down to 35 m. In colour it is generally a reddish brown or fawn above and a lighter shade below.

Astropecten vappa Müller and Troschel

Fig. 1 c

Astropecten vappa Müller and Troschel (1843), p. 119.

Astropecten hartmeyeri Döderlein (1917), p. 156.

Astropecten zebra Sladen (1883), p. 261.

A series of specimens of this species taken from the east and west coasts of Australia indicates that the spination of the supero-marginal plates both with respect to size and number is a variable character. Döderlein (1917, at p. 126) noted that *Astropecten triseriatus* was closely related to *A. vappa* differing only in the armature of the spines upon the supero-marginal plates. Whether *A. triseriatus* is an extreme form of *A. vappa* or is specifically distinct awaits examination of more material from the south-west of Western Australia. The variation in *A. vappa,* summarized in Table 2 is given as a contribution to the solution of the question.

The only reported specimen of *A. triseriatus* from southern Australia taken in Bass Strait (John, 1948 at p. 500) I would refer to *A. vappa.*

The colour of the species is recorded as silver grey dorsally with orange supero-marginal plates for New South Wales' specimens and reddish-brown or fawn dorsally for South Australian specimens.

The habitat of the species is sandy bottom at depths of 3-80 m. In South Australia the species has only been taken in Spencer Gulf and at 12 m. in St. Vincent Gulf off Somerton Beach. It probably ranges right round Australia.

Material Examined:

A. pectinatus

W.A.M. Number 15-66. Ten specimens from west end of Rottnest Island.

T.M. 4 specimens from Pt. Arthur Bay at 30 m.

N.M.V. Number H52 labelled *A. schayeri* from Portland, Victoria and Number H.50.

A.M. J.5420, J.5141, J.7342, J.7091, J.7416 (8 specimens).

S.A.M. K.45 (*A. syntomus*) K.38.

A. preissi

S.A.M. K.697. Thirteen specimens 1½ miles off Pt. Noarlunga, St. Vincent Gulf.

W.A.M. 30 specimens from Shark Bay to King George Sound numbered 61/39, 2-66, 4-66, 5-66, 8-66, 11-66, 14-66, 17-66, 22-66.

A.M. 5 specimens numbered J.7411, J.7420, J.6215 from Garden Island or Green Island, Oyster Harbour.

A. vappa

W.A.M. (13 specimens) Numbered 18-66, 19-66, 20-66, 3-66 from Shark Bay and Rottnest.

A.M. 8 specimens numbered J.7443, J.7340 from Cronulla.

S.A.M. 3 specimens numbered K.44 and K.696.

A. triseriatus

W.A.M. Numbers 832-32, 11-32.

A.M. Number J.7428.

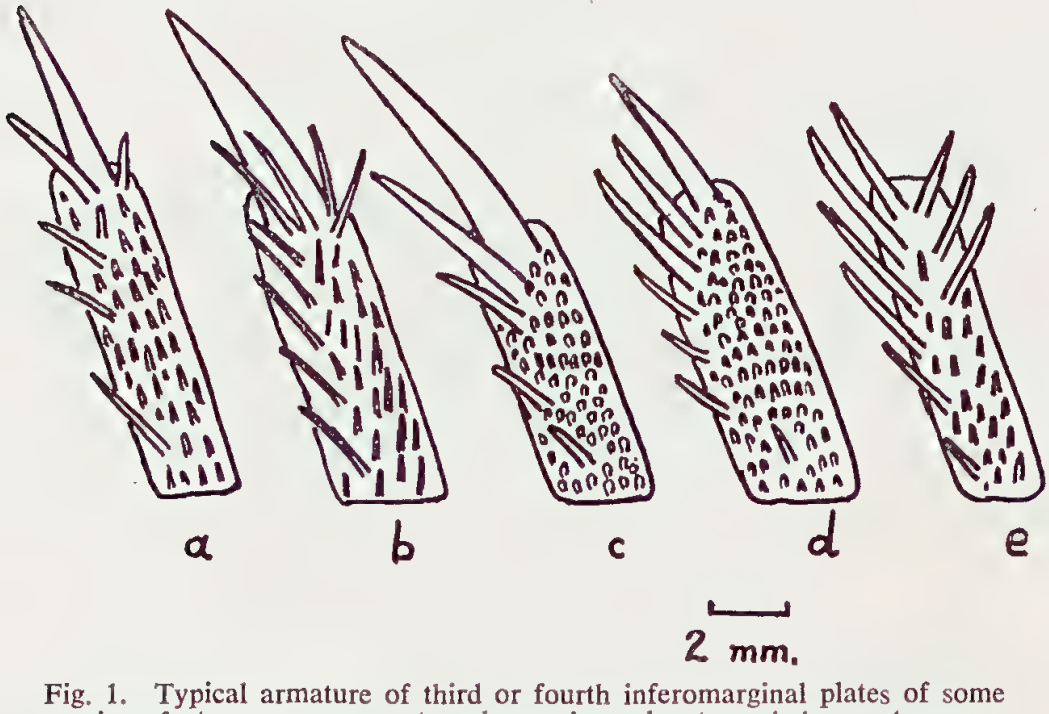


Fig. 1. Typical armature of third or fourth inferomarginal plates of some species of *Astropecten*. a. *A. polyacanthus*. b. *A. preissi*. c. *A. vappa*. d. *A. pectinatus* (specimens from New South Wales and Western Australia). e. *A. pectinatus* specimens from Tasmania showing additional spines.

TABLE 2

Variation in *Astropecten vappa* and *Astropecten triseriatus*

Specimens	Range in R in mm. Range in R/r	Number of Supero-marginal Spines P.—on proximal third of arm. M.—on medial third of arm. D.—on distal third of arm	Length of Supero-marginal Spines along arm in mm.	Number of Spines in Adambu-lacral Armature
12 specimens of *vappa* from Shark Bay, W.A. on sand at 2-4 m.	33-117 3.3-4.9 R/r increases with size	P. Usually 1, sometimes 0, 2 or 3 M. Usually 1 or 2 sometimes 3 D. Usually 1, sometimes 2	0-3.5 usually 2.0	8-12
7specimens of *vappa* from Cronulla, N.S.W. on sand at 10-20 m.	46-98 3.9-4.9 R/r increases with size	P. Usually 1, rarely 2 M. Usually 1 sometimes 0 or 2 D. Usually 1 rarely 2	1.0-2.5 usually 1.5-2.0	7-10
1 specimen of *vappa* from Somerton, St. Vincent Gulf on sand at 12m.	51 4.3	One spine per plate. Rarely on outer margin a second smaller spine	1.5-2.5 usually 2.0	9-11
1 specimen of *vappa* from Lindeman Island Queensland	53 4.5	P. Usually 1, rarely 2 M. None D. None	0.5-1.0	8
1 specimen of *triseriatus* from W.A. (J 7428)	63.5 4.9	P. 1 or 2 M. 2 D. 3	0.5-2.0	8-9
2 specimens of *triseriatus* from near Fremantle, W.A.	62 4.4	P. 1 to 3 M. 2, 3 or 4 D. Usually 1 or 2, occasionally 3	1.0-4.0	8-9

Family OREASTERIDAE

Genus ASTERODISCUS Gray

Asterodiscus truncatus Coleman

Asterodiscus truncatus Coleman (1911), p. 699.

Description: Body large (R may be 150 mm.) with 5 stubby arms. Dorsal surface covered with very large rounded grains up to 6 mm. across.

Remarks: This species known as the "fire-brick seastar" is included here on the basis of one specimen taken in the Great Australian Bight; it it was in poor condition and was dredged at 55 m. off St. Francis Island. In New South Wales the species is known only from rocky bottom and its colour is recorded as purple and red.

The species typically has warm temperate affinities and occurs down to 400 m. along the east coast of Australia as far south as the Tasmanian east coast in deep water. There are also a few records from the Great Australian Bight and Bass Strait in deep water.

Family GONIASTERIDAE

Genus NECTRIA Gray

This genus is represented by four species in South Australian seas. The systematics of the genus were reviewed by Shepherd (1967a) to which account the reader is referred for further information upon the ecology of the several species.

Description: Arms 5. Dorsal surface covered with paxilliform plates, which are densely covered with low granules. Marginal plates not conspicuous and covered with coating of granules.

Key to Species:

1.	Dorsal plates distally on arms individually distinct and similar in form and granulation to those on disk	2
	Not as above: dorsal plates distally difficult to distinguish individually; covered with coating of low grains	3
2.	Colour pale yellow to orange. Tips of arms brown	*macrobrachia*
	Colour bright red; papulae black	*saoria*
3.	Dorsal paxilliform plates well-spaced, covered with hemispherical granules	*ocellata*
	Dorsal paxilliform plates very crowded and covered with closely packed polygonal flat-topped granules	*multispina*

Nectria ocellata Perrier

Nectria ocellata Perrier (1876), p. 4.

As yet the species has only been taken in Backstairs Passage, St. Vincent Gulf at 30-50 m.

Nectria macrobrachia H. L. Clark

Nectria macrobrachia H. L. Clark (1923), p. 236.

The species is common along the exposed rocky coasts of South Australia down to 60 m.

Nectria multispina H. L. Clark

Nectria multispina H. L. Clark (1928), p. 375.

This species is common both on exposed rocky coasts and on the more sheltered reefs of Spencer and St. Vincent Gulfs. It is variable in colour ranging from yellow to dark red.

Nectria saoria Shepherd

Nectria saoria Shepherd (1967), p. 463.

Saoria has some superficial resemblance with *Nectria multispina*. However, the black colour of its papulae and their occurrence throughout the length of the arms makes it readily distinguishable. In the field, *multispina* is rarely found in the surge zone in exposed localities, whereas *saoria* is restricted to this habitat.

Family GONIASTERIDAE

Genus PENTAGONASTER Gray

Pentagonaster duebeni Gray

Pentagonaster dübeni Gray (1847), p. 79; A. M. Clark (1953), p. 400.

Description: Five arms. Body form more or less pentagonal but with extended vertices. Body flattened above and below and covered with rounded plates forming a firm pavement. Marginal plates large and prominent, 4 (rarely 3) to 10 on each side of each arm (*i.e.*, 8 to 20 across each interbrachial arc). Maximum R is 73 mm.

Pedicellariae present with 2-3 narrow valves on dorsal and ventral plates.

Remarks: There is now no doubt that the South Australian form is conspecific with the form from Western Australia, the locality of Gray's type. A series of specimens from St. Vincent Gulf between Aldinga and Cape Jervis shows a range of variation which embraces the forms formerly known as *P. crassimanus, P. stibarus* and *P. gunni*. In the South Australian specimens the number of marginal plates increases in general with size, although there is some variation in individual specimens (see Table 3). Furthermore, it is observed that specimens tend to increase in size with depth so that the *gunni*-like form with longer and more pointed arms occurs predominantly in deep water of 30 m. or more.

The form whose distal supero-marginal plates are grossly enlarged as in the figure of A. M. Clark ((1966), p. 355, pl. 4) is a variant common in South Australia's Eastern Bays and in Victoria in shallow submarine caves. It has not been recorded elsewhere on the South Australian coast.

TABLE 3

Variation in *Pentagonaster duebeni*

Number of Specimens	Locality	Range in R (in mm.)	Extreme Range in R/r Mean R/r ± 1 S.D.	Supero-marginals % occurrence in Sample					
				3	4	5	6	7	8-10
15	Port Noarlunga to North Coast Kangaroo Island St. Vincent Gulf	41-73	2.0-2.9 2.4 ± 0.24	—	6%	56%	26%	6%	6%
15	Port Noarlunga to North Coast Kangaroo Island St. Vincent Gulf	25-42	1.9-2.2 2.08 ± 0.1	—	40%	51%	9%	—	—
3	Robe, S.A.	39-44	1.8-2.2	66%	33%	—	—	—	—

The colour of the species is always bright and ranges from yellow through orange to red. Sometimes the plates are outlined prettily in milk white but more commonly in a dull green or yellow.

The habitat of the seastar is on reefs or rocky bottom and among an association of encrusting organisms comprising sponges, bryozoa and compound ascidians. Thus it is usually found on vertical rock surfaces and under overhanging ledges where such encrusting organisms become dominant. The starfish is often taken grazing on these organisms encrusting the rock face. On exposed coasts subject to strong wave action the species is only found below the zone of strong surge, *i.e.*, below about 10 m. but on more protected shores it may occur in shallow water of 1 or 2 m. depth.

The species ranges from Western Australia to Queensland around the southerly half of the Continent and is reported down to 200 m. It probably occurs on most of the South Australian rocky coastline except in the upper reaches of the Gulfs and in sheltered bays.

Genus TOSIA Gray

The confused nomenclature of this genus has now been satisfactorily resolved by Clark (1953, p. 403). There are two species from South Australian seas. The second of them (*T. magnifica*) is doubtfully included here as it has not yet been taken in depths accessible to a diver in South Australia.

Description: Five arms; pentagonal in shape or nearly so. Body flattened above and below and covered with rounded plates forming a firm pavement.

Marginal plates conspicuous forming outline of body.

Pedicellariae resemble a split granule but are infrequent.

Key to Species:

3 plates on each side of arm (or 6 along each side) *australis*

4-8 plates on each side of arm (8-16 along each side) . . . . . *magnifica*

Tosia australis Gray

Tosia australis Gray (1840), p. 281; Livingstone (1932), p. 375; A. M. Clark (1953), p. 379.

Tosia astrologorum Cotton and Godfrey (1942), p. 198.

A large series has been collected by the author and it is now clear that the variation in the species is ecological in origin. Recent collections do not support H. L. Clark's suggestion (1946 at p. 94) that widely different forms may be found in the same locality. Populations from any one place have been found to be homogeneous but comparison of samples from populations of differing habitats shows that there are many intermediate forms between the extremes. This is illustrated in Table 4 where three population samples are analysed.

The morphological variation relates to the degree of convexity of the dorsal plates and the degree of swelling of the terminal supero-marginal plates (see Table 4). These differences are not apparent in juvenile specimens.

TABLE 4

A comparison of 3 population samples from different habitats. Only adult specimens where R > 25 mm. are used.

The degree of swelling of the terminal supero-marginal plates is estimated by taking the ratio of the surface area of the plate to that of the innermost supero-marginal plate.

Number of Specimens	Locality	Depth	Habitat	Extreme Range in R/r Mean R/r	Swelling of terminal Supero-marginal Plate (*a*) Extreme range (*b*) Mean ± 1 S.D.
13	West Island Encounter Bay (*astrologorum*-like form)	10-15m.	Strong to extreme wave action	1.4-1.8 1.65	(*a*) 2.8-5.4 (*b*) 3.9 ± 0.95 Very swollen
22	Glenelg breakwater St. Vincent Gulf	2-5m.	Slight to moderate wave action	1.4-1.7 1.52	(*a*) 1.5-2.8 (*b*) 2.2 ± 0.44 Slightly swollen
8	Kingscote jetty Kangaroo Island	4-7m.	Very calm water	1.2-1.7 1.4	(*a*) 0.9-2.1 (*b*) 1.65 ± 0.40 Not swollen

In localities of strong to extreme wave action the *astrologorum*-like form occurs but only at depths below about 8 m. Like *Pentagonaster duebeni* it prefers vertical or slightly overhanging rock surfaces, although it is occasionally found on horizontal or sloping rocky surfaces under the algal canopy. Specimens from this habitat are not highly coloured but are usually varying shades of brown.

In less exposed localities, as in the sample from the Glenelg Breakwater, St. Vincent Gulf, the form with only slightly enlarged distal supero-marginals commonly occurs on reefs down to about 10 m. often under a canopy of the laminarian *Ecklonia* or other brown algae. Such specimens are usually highly coloured, the dorsal surface presenting a kaleidoscopic mosaic of purples, mauves, oranges and salmon pink colours. The ventral surface is a cream or light salmon colour.

In calm waters and land-locked bays the form without enlarged (although sometimes elongated) terminal supero-marginal plates occurs in large numbers on sandy bottoms in *Halophila* and *Zostera* beds typical of calm conditions. Specimens from this habitat are not multicoloured but are a uniform salmon, mauve or brown colour. It ranges here from just below low tide to about 10 m. This form is commonly found in Port Lincoln Harbour, Edithburgh, Nepean Bay on Kangaroo Island and the upper sheltered waters of St. Vincent and Spencer Gulfs. The species feeds variously on detritus, molluscs and rock-encrusting ascidians and bryozoa.

Tosia australis ranges from the region of Streaky Bay, South Australia, to the New South Wales coast and occurs around Tasmania.

Tosia magnifica (Müller and Troschel)

Astrogonium magnificum Müller and Troschel (1842), p. 53.

Tosia magnifica A. M. Clark (1953), p. 408.

As yet this species has only been dredged in deep water off the South Australian coast. The only specimen which I have seen was taken by the Soviet vessel *Akademik-Berg* at about 200 m. off the south coast of Kangaroo Island in 1966. It was a light salmon colour. As it is known from water of 5 m. depth in D'Entrecasteaux Channel, Tasmania, and is common in Port Phillip Bay, Victoria it may yet be found at less than 60 m. in the Eastern Bays of South Australia. The Port Phillip Bay specimens are a uniform dull brown and occur on a sandy or mud bottom.

Family ANTHENEIDAE

Genus ANTHASTER Döderlein

Anthaster valvulatus (Müller and Troschel)

Oreaster valvulatus Müller and Troschel (1843), p. 115

Anthaster valvulatus Döderlein (1915), p. 27

Description: Body large and convex dorsally, 5 stubby arms. Marginal plates prominent forming outline of body. Plates on dorsal surface covered with fine granules. 5-12 large smooth tubercles protrude from some plates usually radially along line of arm. Maximum R is about 120 mm.

Remarks: *Anthaster valvulatus* is common along the eastern margin of Spencer Gulf on reefs between Wardang Island and Point Riley near Wallaroo from 3 to 10 m., and further north on the opposite coast at Point Lowly.

At Goose Island, near Wardang Island, *Anthaster* was found in areas of moderate surge where the rock was encrusted with sponges, compound ascidians and lithothamnia. Observations indicated that it fed on such encrusting sponges and ascidians. Elsewhere the species, although uncommon, does occur on muddy bottom at 40 m. and in *Posidonia* beds at 10 m. in St. Vincent Gulf and on rocky substrate in Investigator Strait at 20-40 m.

In colour it is a brick red sometimes with mottling above with the lower surface a cream or light salmon colour.

The range of the species is from Fremantle, Western Australia to St. Vincent Gulf, South Australia.

Family ASTEROPIDAE

Genus PETRICIA Gray

Petricia vernicina (Lamarck)

Asterias vernicina Lamarck (1816), p. 554

Petricia vernicina Fisher (1908), p. 357.

Petricia obesa H. L. Clark (1923), p. 241.

Description: Arms 5, short stubby and rounded at tip. Body and arms covered by thick smooth skin concealing marginal plates.

Remarks: This seastar is ubiquitous on South Australia's rocky shores. On exposed coasts it may be found under crevices and ledges in a similar habitat to that favoured by *Pentagonaster duebeni* and is the only species of asteroid which penetrates the extremities of submarine caves. On less

exposed coasts it occurs commonly on shallow reefs often under the canopy of *Ecklonia* or *Cystophora* spp. at 1 or 2 m. The species has also been taken at depths of 60 m. on rocky bottom dominated by a sponge association.

This species' favourite diet seems to be encrusting sponges on which it is often found grazing, but it probably also feeds on other rock encrusting organisms and detritus.

Petricia is usually mottled in colour and varies from dull brown to a brilliant orange or red. Specimens taken in places of reduced illumination such as from the back of caves or in deep water are a much brighter colour than others taken in shallow water.

I regard *Petricia obesa* as a synonym of *P. vernicina* (see A. M. Clark 1966, p. 318) so that the range of the species is from the Abrolhos Islands, Western Australia to Caloundra, Queensland (Endean, 1957).

Family OPHIDIASTERIDAE

Genus AUSTROFROMIA H. L. Clark

Austrofromia polypora (H. L. Clark)

Fromia polypora H. L. Clark (1916), p. 51.

Austrofromia polypora H. L. Clark (1946), p. 114.

Description: Arms 5, long, slightly tapering and round in cross-section. Surface covered with irregularly arranged plates which are coated with low granules. Maximum R is 80 mm.

Remarks: *Austrofromia* is always associated with rocky areas encrusted by sponge growth, and its feeding habits parallel those of *Pentagonaster duebeni*.

On the open coasts it is not uncommon in deeper rocky areas below about 20 m. and in St. Vincent Gulf it occurs on the numerous off-shore reefs from 5 to 20 m. between Aldinga and West Beach. However, Bennett and Pope (1953) report its occurrence intertidally on the cooler Victorian coasts.

The colour of the living animal is bright yellow and its black papulae protrude individually between the plates giving it a distinctive speckled appearance; specimens I have seen from Port Hacking, New South Wales, were a dark red in colour. The species has a distribution from Rottnest, Western Australia around the Victorian and Tasmanian coasts to Port Hacking, New South Wales and has been dredged down to 160 m.

Order SPINULOSA

Family ASTERINIDAE

Genus ASTERINA Nardo

Asterina atyphoida H. L. Clark

Asterina atyphoida H. L. Clark (1916), p. 57; A. M. Clark (1966), p. 324.

Description: Arms 5, pentagonal in shape. Dorsal surface covered with small round or oval plates with fine peripheral spinelets on them. Maximum R is about 12 mm.

Remarks: Little more is known of this seastar since Dr. Verco dredged extensively in Spencer and St. Vincent Gulfs. The lack of specimens from depths less than 40 m. suggests that it is largely confined to waters deeper than this. I have taken several specimens at 30-40 m. among sponge material on rocky bottom in Backstairs Passage, St. Vincent Gulf. This asterinid is small and inconspicuous; specimens are usually discovered concealed among sponge or rock while bottom material is being sorted out on deck. The colour in life is usually a pale cream, yellow or light brown. Its known range is from the South Australian Gulfs to Port Phillip Heads, Victoria.

Genus PATIRIELLA Verrill

This genus is represented in South Australian seas by four species.

Description: Disk large arms and body more or less flattened. Sides only slightly concave if at all. Dorsal surface covered with crescentic plates which are covered with low granules. Three species are figured in Dakin (1960) plates 80, 81.

Key to Species:

1. Pentagonal in form. Five arms, size small (R up to 10 mm.), colour blue-green or green ..	*exigua*
Arms 6 or 8	2
2. Arms 8. Interbrachial arcs deeper than other species. Ventral plates carry only one spine. Vari-coloured	*calcar*
Arms 6	3
3. Dorsal colour rich purple. Tube feet orange ..	*brevispina*
Dorsal colour blue, dark and light red, brown or cream; tube feet cream or white	*gunni*

Patiriella carcar (Lamarck)

Asterias calcar Lamarck (1816), p. 557.

Patiriella calcar Verrill (1913), p. 484.

This species is one of the few seastars which is limited to the intertidal or immediately sub-littoral zone. It is gregarious in habit and flourishes in great numbers in protected rock pools on exposed coasts but becomes progressively less common up the Gulfs; in St. Vincent Gulf it is rarely seen north of Port Willunga and in Spencer Gulf north of Corny Point. This species appears to be omnivorous and feeds on detritus, algae (in particular *Laurencia* sp. and *Gelidium* sp.) gastropods and pelecypods. It also scavenges moribund animals which may be washed within its reach.

The seastar is remarkable for its diversity of colour and may be seen in combinations of white, yellow, orange, red, brown and grey. Its coloration is well illustrated by Dakin (1960, pl. 82).

The range of the species is from King George Sound, Western Australia around Tasmania to Currumbin, Queensland.

Patiriella exigua (Lamarck)

Asterias exigua Lamarck (1816), p. 554.

Patiriella exigua Verrill (1913), p. 484.

This curious little seastar might easily be overlooked in shore collecting. Like *P. calcar* it appears to be restricted to an intertidal habitat and occurs in shallow rock pools on sheltered coasts and also in very shallow water among mangrove roots in the upper reaches of Spencer and St. Vincent Gulfs. It is able to withstand surprisingly high summer temperatures often in the region of 30-35°C. in water sometimes only 1 or 2 cm. deep. It is gregarious and in suitable conditions many hundreds may occur within a single pool. The species is uniformly dark blue-green dorsally with a lighter colour below. Whitelegge (1889 at p. 201) describes the breeding of this species in New South Wales.

In addition to the localities mentioned by Cotton and Godfrey (1942) the species has been found at Port Minlacowie, Yorke Peninsula and at numerous localities intertidally between Port Gawler and Port Wakefield, St. Vincent Gulf.

Exigua occurs along the southern Australian coast from Spencer Gulf to Tasmania and along the eastern coast of Australia to Torres Strait.

Patiriella gunni (Gray)

Asterina gunnii Gray (1840), p. 289.

Patiriella gunni (Gray); Verrill (1913), p. 484; A. M. Clark (1966), p. 320.

This *Patiriella* is small and secretive, and occupies a discrete habitat under rocks from just below low tide in protected areas down to about 10 m. Specimens have occasionally been taken in deeper water down to 30 m. Its feeding habits are similar to those of *Paranepanthia grandis.*

The species is almost as diversely coloured as *P. calcar* and appears in mottled shades of red, pink, blue, light brown, or cream.

The species is abundant at Wedge Island, Spencer Gulf in shallow water near the jetty under rocks at 1 m., at Port Noarlunga at 6 m. to the north of the reef, and at Port Willunga reef in shallow water under rocks.

Gunni is found along the southerly half of the continent from Dongarra on the western coast of Western Australia around Tasmania to Long Reef Collaroy New South Wales.

Patiriella brevispina H. L. Clark

Patiriella brevispina H. L. Clark (1938), p. 166; Bennett and Pope (1953), p. 149.

In morphology this species is indistinguishable from the preceding although it does grow to a considerably larger size (maximum R is up to 70 mm.). In the field, however, the two species cannot be confused; they occupy very different habitats and *brevispina* is always a rich purple in colour whereas *gunni* never is.

Brevispina is a common seastar of shallow water occurring both on rocky and sandy bottom along the margins of St. Vincent and Spencer Gulfs down to 10 m. and in sheltered locations along the exposed coasts. Large numbers are washed ashore annually on the sandy beaches of South Australia during November and December.

This species is a voracious feeder and has been observed feeding on red algae (*Laurencia* sp. and *Spyridium* sp.) pelecypods and gastropods. It will also scavenge decaying animals and bottom detritus. The species' range is from Fremantle, Western Australia to Sydney Harbour, New South Wales and it is recorded from the north coast of Tasmania.

Genus PARANEPANTHIA Fisher

Paranepanthia grandis (H. L. Clark)

Nepanthia grandis H. L. Clark (1928), p. 393.

Paranepanthia grandis H. L. Clark (1938), p. 159.

Description: Arms 5; more or less pentagonal. Dorsal surface covered with small rounded plates bearing fine spinelets. Maximum R for South Australian specimens is about 45 mm.

Remarks: Judging from the specimens dredged by Verco, *Paranepanthia* is not rare in deeper water and I have taken a number of specimens at 30-40 m. on rocky bottom in Backstairs Passage. In shallow water the species is seldom seen but may occasionally be found on open coasts well-hidden under rocks in places locally protected from the swell. Specimens taken at West Island, Encounter Bay at 2-3 m. were found feeding on small gastropods and on compound ascidians which encrust the undersurface of rocks.

The species is a pale pink to orange above sometimes with mottling, and cream below.

It has a southerly distribution around Australia from Point Peron Western Australia to Sydney Harbour New South Wales, and occurs also in Tasmanian waters.

Genus NEPANTHIA Gray

Nepanthia troughtoni (Livingstone)

Parasterina troughtoni Livingstone (1934), p. 179.

Parasterina occidentalis H. L. Clark (1938), p. 180.

Parasterina sp. ? *troughtoni* A. M. Clark (1956), p. 379.

Nepanthia hadracantha A. M. Clark (1966), p. 289.

Description: Disk small; 5 long slightly tapering or cylindrical arms. Surface of seastar closely paved with more or less rhombic plates, often imbricated, which in turn are densely covered with a coat of minute spinelets.

Remarks: The comparison of specimens from Western Australia, Victoria and South Australia enables me to clarify the confusion in the name of this species.

There is some variation in both Western Australian and South Australian specimens in

(*a*) the relative size and crowding of the dorsal plates on the disk and at the base of the arms and

(*b*) the degree of taper of the arms.

In some specimens the plates are not at all crowded and the papulae may be easily seen between them. In others the plates are distinctly rhombic and densely crowded. The tapering of the arms is a variable character. In most adult specimens tapering is quite evident but in some juvenile specimens the arms taper very little or not at all. As the differences between *P. troughtoni* and *P. occidentalis* are based on these variable characters and are in any event vague I have no difficulty in following A. M. Clark's suggestion (1956 at p. 380) that *P. occidentalis* is a synonym of *P. troughtoni.*

The specimens examined also agree well with the descriptions of *Nepanthia hadracantha* (A. M. Clark (1966), p. 289) and *Parasterina* sp. ? *troughtoni* both taken in Victorian waters. The figures of the dorsal spinelets of *Nepanthia hadracantha* (A. M. Clark (1966), p. 321) are typical of the spinelets of both the Western Australian and South Australian series. There is however rather more variation in the spinelets in the species than appears from the figures. In some specimens in addition to the typical spinelets there may also occur spinelets having several sharply pointed needle-like projections instead of the usual single enlarged conical or blunted process in the centre of the spinelet. It is clear that *Nepanthia hadracantha* is a synonym of *Parasterina troughtoni.*

As to the generic location of the species, apart from the doubts cast upon the usefulness of retaining the genus at all by Fisher (1941, p. 66) the absence of secondary dorsal plates indicates that this species falls more naturally into the genus *Nepanthia.*

Like *Nectria saoria* the species is restricted to areas of strong wave action and is found between depths of 5 and 30 m. The species occurs so consistently in this habitat that it may be considered an indicator organism of such conditions. It may be expected anywhere along the exposed coast but does not penetrate far up Spencer or St. Vincent Gulfs. In St. Vincent Gulf it has not been recorded north of Rapid Head nor in Spencer Gulf north of Goose Island near Port Victoria. In Western Australia however, the species shows some diversity of habitat and is recorded on sandy bottom and also under rocks.

This *Nepanthia* grazes over the rock face and feeds on lithothamnia, encrusting bryozoa, sponges and compound ascidians.

The colour of South Australian specimens is usually an off-white or very pale pink but Western Australian specimens are much brighter being frequently a rose red in colour. The known range of the species is from Fremantle, Western Australia to Wilson's Promontory, Victoria.

Material Examined:

W.A.M. 20 specimens numbered 9508, 20-59, 29-59, 23-66 to 28-66, 47-32, taken on the Western Australian coast between Trigg Island and King George Sound, Western Australia.

S.A.M. 26 specimens numbered K680, K616, K606 from West Island and Wright Island, Encounter Bay; Troubridge Point, Yorke Peninsula; Goose Island, Spencer Gulf; and the north coast of Kangaroo Island.

N.M.V. H. 53 from Wilson's Promontory, Victoria.

Family ECHINASTERIDAE

Genus ECHINASTER Müller and Troschel

Description: Disk small; 5 long tapering arms, round in cross-section. Dorsal surface covered with skin and bearing spines either isolated or in clusters.

Key to Species:

Dorsal spines in clusters. Dark red colour. Maximum R = 90 mm. . . . . *glomeratus*

Dorsal spines isolated and forming coarse meshes. Colour dull yellow to red. Maximum R = 150 mm. . . . . *arcystatus*

Echinaster arcystatus H. L. Clark

Echinaster arcystatus H. L. Clark (1914), p. 148.

This *Echinaster* is a large and well marked species inhabiting rocky bottom below 30 m. It is only occasionally seen in shallow water.

The species has been observed to feed on encrusting sponges and less often on molluscs and detritus. As sponges are usually dominant in rocky areas of 30 m. or more it is likely that this constitutes a substantial part of its diet.

Living specimens are variable in colour ranging from a rather dull yellow to dark red; their characteristic slipperiness to the touch is imparted by the dense groups of papulae which protrude from within the meshes over the surface of the animal. The species has been recorded from most of the off-shore reefs in St. Vincent Gulf south of Halletts Cove in depths of 10 to 30 m., from West Island at 30 m. and from Investigator Strait.

It ranges from Western Australia, south of Geraldton to Encounter Bay, South Australia.

Echinaster glomeratus H. L. Clark

Echinaster glomeratus H. L. Clark (1916), p. 62.

This endemic South Australian species is rarely encountered by skin-divers. Like *E. arcystatus* it occurs on rocky bottom but has only been taken in the region of Cape Jervis at 20-30 m. In colour it is a dark wine red. Nothing is known of its feeding habits or its distribution.

Genus PLECTASTER Sladen

Plectaster decanus (Müller and Troschel)

Echinaster decanus Müller and Troschel (1843), p. 114.

Plectaster decanus Sladen (1889), p. 535.

Description: Arms 5, tapering, round in cross-section. Low thick granules form the outline of a coarse prominent meshwork over the surface of the seastar. Photographed in Dakin (1960), pl. 81.

Remarks: This unusual species is a little better known than the preceding; it may be expected, although not commonly, on reefs in the lower half of Spencer and St. Vincent Gulfs. The only place where large numbers are known to occur is at Goose Island, Spencer Gulf on exposed reefs at 2 to 6 m. Limited observations suggest that it feeds on encrusting sponges and ascidians. This *Plectaster* ranges from the Great Australian Bight to Newcastle, New South Wales, down to 200 m.

Family ASTERIIDAE

Genus COSCINASTERIAS Verrill

Coscinasterias calamaria (Gray)

Asterias calamaria Gray (1840), p. 179.

Coscinasterias calamaria Perrier (1894), p. 106.

Description: Arms 7 to 14. Small specimens usually 9 and adults 11. Dorsal spines isolated and prominent. Figured in Dakin (1960), plates 79, 80. Maximum R is 250 mm.

Remarks: This, the largest and most ubiquitous seastar of South Australian areas, occurs on rocky, sandy or muddy bottom provided there is some protection from the surge of the ocean swell. In Spencer and St. Vincent Gulfs it is common on shallow water reefs along the coastal margins, and on *Halophila* beds, *Pinna* beds and muddy bottom at 20-50 m.

Specimens from shallow water are usually blue or grey, often mottled, but deep water specimens are bright orange to red. *Coscinasterias* is an avid predator and will attack a variety of molluscs including the razor shell *Pinna dolobrata* and the elephant snail *Scutus*; it will also prey on moribund

animals and scavenge debris. Bennett (1927) discusses the behaviour and autotomy of the species in New Zealand water. In southern Tasmania it is recorded by Olsen (1957) as the main predator of the scallop.

The species ranges from South Africa to New Zealand; on the Australian coast its known northerly limits are Rottnest Western Australia and Pt. Danger, Queensland (Endean 1965).

Genus ALLOSTICHASTER Verrill

Description: The two species are small; R seldom exceeds 35 mm. Dorsal surface covered with spines in definite longitudinal series. Figured in Dakin (1960), p. 179.

Allostichester polyplax (Müller and Troschel)

Asteracanthion polyplax Müller and Troschel (1844), p. 178.

Allostichaster polyplax Verrill (1914), p. 363; A. M. Clark (1962), p. 102.

This small and rather secretive seastar is abundant in rocky areas on protected coasts. It is usually to be found concealed under boulders and occurs most commonly from the intertidal zone down to about 10 m. Small gastropods and pelecypods are included in its diet.

It is commonly seen intertidally at Port Willunga and at Port Noarlunga Reef, Glenelg Breakwater at 3 m. and Halletts Cove at 5-10 m.

In addition to normal reproduction the species is fissiparous and very often specimens are taken with two, three, four or five regenerating arms. This phenomenon has been studied by Bennett (1927). In colour the species is more or less a uniform dull brown to grey. The species ranges from Rottnest Western Australia to New Zealand down to 128 m.

Allostichaster regularis H. L. Clark

Allostichaster regularis H. L. Clark (1928), p. 400.

In contrast to the preceding species *A. regularis* is regularly pentamerous. The slight morphological differences between the two species are given by A. M. Clark (1962 at p. 102). The species although seldom taken, appears to occupy a similar habitat to *A. polyplax*.

Genus SMILASTERIAS Sladen

Smilasterias irregularis H. L. Clark

Smilasterias irregularis H. L. Clark (1928), p. 402.

Description: Arms 5; spinelets scattered over dorsal surface but in no regular series. Maximum R is about 50 mm.

Remarks: This species is as secretive as *Allostichaster polyplax* but is much less frequently encountered. It autotomizes readily and specimens

are often found with one or more arms missing or regenerating. It is found in a similar habitat to that occupied by *A. polyplax* and has been observed to feed on small gastropods and chitons which are similarly concealed under rocks.

In colour the species is a pretty variegated dark and light red dorsally. It is superficially very similar to *Allostichaster regularis* but may be distinguished from it in that its disk is more plainly convex and distinct from the arms and its colour is quite different.

Specimens have been taken at Sunken Brother Rock, Port Lincoln Harbour at 6 m., Bamboo Reef near Balgowan, Yorke Peninsula at 5 m., and Port Noarlunga Reef and Port Willunga Reef, St. Vincent Gulf. The range of the species is from Spencer Gulf to Port Phillip Bay, Victoria. Either it or a closely related species is recorded from Macquarie Island (A. M. Clark, 1962, at p. 87).

Genus UNIOPHORA Gray

This genus was recently revised by Shepherd (1967b) and the notable variability of the two species and their ecology is there discussed.

Key to Species:

Dorsal surface covered by a network of spines, often capitate. Longitudinal series along centre of ray prominent. (Figured in Dakin (1960), pl. 81 . . . . . *granifera*

Few spines dorsally. Where existing they are short and pointed . . . . . *nuda*

Uniophora granifera (Lamarck)

Asterias granifera Lamarck (1816), p. 560; Shepherd (1967b), p.

Uniophora granifera Bell (1881), p. 497; H. L. Clark (1928), p. 403.

This is one of the most abundant of the asteroids of the rocky reefs in St. Vincent and Spencer Gulfs. It occurs in places of moderate wave action and commonly feeds on the ascidians *Pyrura irregularis* and *Microcosmus stolonifera.*

Uniophora nuda (Perrier)

Asterias nuda Perrier (1875), p. 335.

Uniophora nuda Fisher (1926), p. 198; Shepherd (1967), p. 1.

Further collecting may yet show that this species intergrades completely with *granifera.* At present the morphological and habitat differences are sufficient to justify the separation of the two species. The species is

most commonly seen on *Halophila* beds down to 60 m. where it feeds on solitary ascidians and molluscs. It is known only from the lower regions of the South Australian Gulfs.

BIOGEOGRAPHIC NOTES

The Flindersian biogeographic province is considered to be a transitional warm temperate region extending from the south-western corner of Western Australia to the region of Robe, South Australia according to Knox and others (see Knox 1963, p. 375); Womersley and Edmonds (1958) however consider that the eastern bays of South Australia and the Victorian and Tasmanian coasts comprise a sub-province with marked cool temperate affinities within the Flindersian province extending to the far eastern Victorian coast.

The distribution of the 31 species of asteroids in the Flindersian region is as follows:

1. Endemic to central region (*i.e.*, from Streaky Bay to Robe) (*Uniophora nuda, Allostichaster regularis, Echinaster glomeratus*) 3
2. Eastern and central region (*i.e.*, not extending west of the head of the Great Australian Bight) (*Smilasterias irregularis, Nectria multispina, Patiriella exigua, Asterina atyphoida, Tosia australis, Uniophora granifera*; the latter two species have related allopatric species in Western Australia) 6
3. Central and western region (*i.e.*, not extending east of Encounter Bay) (*Astropecten preissi, Anthaster valvulatus, Echinaster arcystatus*) 3
4. Eastern region (*i.e.*, not extending west of Robe, South Australia) (*Australiaster dubius, Asterina inopinata, Tosia magnifica*) 3
5. General southern Australian distribution (except in some cases southern Tasmania) 19

It is evident that two critical regions in the biogeography of shallow water asteroids are the region westward from the head of the Great Australian Bight, and the south-eastern coast of New South Wales. The differences on the cooler Victorian and Tasmanian coasts are comparatively minor.

The distribution of asteroids emphasizes the homogeneity of the whole of the southern Australian coast as far as this group is concerned and provides no evidence for the creation of a separate and distinct biogeographic province for the Victorian and Tasmanian coasts as advocated by Bennett and Pope (1953).

ACKNOWLEDGMENTS

I am grateful to the officers of the Museums referred to in this paper who made available their respective collections, and to Mr. A. J. Dartnell who supplied distributional data from Tasmania.

TABLE 5

A summary of the species according to habitat on South Australian coasts

INTERTIDAL ROCK

Allostichaster polyplax
Coscinasterias calamaria
Patiriella calcar
Patiriella exigua
Patiriella gunni

SUB-LITTORAL SAND OR MUD

Anthaster valvulatus
Astropecten pectinatus
Astropecten preissi
Astropecten vappa
Coscinasterias calamaria
Luidia (Maculaster) australiae
Patiriella brevispina
Uniophora nuda

SUB-LITTORAL SAND OR ROCK
(found only over 30 m.)

Asterina atyphoida
Asterodiscus truncatus
Nectria ocellata
Tosia magnifica

SUB-LITTORAL ROCK

(*a*) Sheltered Localities

Allostichaster polyplax
Allostichaster regularis
Anthaster valvulatus
Coscinasterias calamaria
Nectria multispina
Paranepanthia grandis
Patiriella brevispina
Patiriella gunni
Pentagonaster duebeni
Smilasterias irregularis
Uniophora granifera

(*b*) Exposed Localities

Austrofromia polypora
Echinaster arcystatus
Echinaster glomeratus
Nectria macrobrachia
Nectria multispina
Nectria saoria
Nepanthia troughtoni
Pentagonaster duebeni
Petricia vernicina
Plectaster decanus

TABLE 6

Species recorded on the southern Australian continental shelf. (See H. L. Clark (1946) and A. M. Clark (1962).)

Australiaster dubius
Cosmasterias dyscrita
Crossaster multispinus
Dipsacaster magnificus
Henricia hyadesi
Lonchotaster forficifer
Lonchotaster magnificus
Marginaster c.f. paucispinus
Mediaster australiensis
Nymphaster pentagonus
Odinia australis
Pseudophidiaster rhysus
Psilaster acuminatus
Pteraster tetracanthus
Radiaster gracilis
Stylasterias reticulata
Zoroaster macracantha

REFERENCES

Bell, F. J., 1881: Proc. Zool. Soc. London, p. 497.
Bennett, E. W., 1927: Rec. Canterb. Mus., 3, p. 125.
Bennett, I. and Pope, E. C., 1953: Aust. J. Mar. Freshw. Res., 4, pp. 105-159.
Clark, A. M., 1953: Bull. Br. Mus. (nat. Hist.), Zool. 1, pp. 379-412.
———— 1956: Ann. Mag. Nat. Hist. (12) 9, pp. 374-383.
———— 1962: B.A.N.Z.A.R.E. Rep. Ser. B., Vol. 9, pp. 1-102.
———— 1966: Mem. Nat. Mus. Vict., No. 27, pp. 289-351.
Clark, H. L., 1914: Rec. W. Aust. Mus., Vol. I, pp. 132-173.
———— 1916: Endeavour Rept., pp. 1-123.
———— 1921: Ech. Torres Strait, pp. 1-224.
———— 1923: Jour. Linn. Soc. (Zool.), Vol. 35, pp. 229-251.
———— 1928: Rec. S. Aust. Mus., Vol. 3, pp. 108-142.
———— 1938: Mem. Mus. Comp. Zool., 55, pp. 1-597.
———— 1946: "The Echinoderm Fauna of Australia". Publ. Carneg. Inst., 566, 1-567.

Coleman, H. L., 1911: Mem. Aust. Mus., 14, p. 699.
Dakin, W. J., 1960: Australian Seashores (Revised Edition).
Döderlein, L., 1915: Jahrb. Nassau Ver. Naturk. Wiesbaden, Vol. 68, p. 27.
———— 1917: "Siboga" Ast: pp. 1-191.
———— 1920: Siboga Rep. Ast., p. 266.
Endean, R., 1957: Aust. J. mar. Freshw. Res., 8, pp. 233-273.
———— 1965: Pap. Dep. Zool. Univ. Qd., 2, p. 230.
Fell, H. B., 1963: Phil. Trans. Roy. Soc. Lond. Ser B 246, pp. 381-435.
———— 1966: Oceanogr. Mar. Biol. Ann. Rev., 4, 233-245.
Fisher, W. K., 1908a: Zool. Anz., Vol. 33, pp. 356-359.
———— 1908b: Smithsonian Misc. Coll., Vol. 52, p. 90.
———— 1917: Ann. Mag. Nat. Hist. Ser. 8, Vol. 20, p. 172.
———— 1926: Ann. Mag. Nat. Hist., Vol. 18. p. 198.
———— 1930: Bull. U.S. Nat. Mus., 76: 1-81.
———— 1941: Proc. U.S. Nat. Mus., Vol. 90, pp. 447-456, p. 170, Fig. 2.
Gray, W. E., 1840: Ann. Mag. Nat. Hist., Vol. 6, pp. 175-184, 275-290.
———— 1847: Proc. Zool. Soc. London Pt. 15, p. 79.
John, D. D., 1948: Novit. Zool., 42: pp. 485-508.
Knox, G. A., 1963: Oceanogr. Mar. Biol. Ann. Rev. 1, pp. 341-404.
Lamarck, J. B. P., 1816: Anim. sans vert., Vol. 2, pp. 522-568.
Livingstone, A., 1932: Rec. Aust. Mus., Vol. 18, p. 375.
———— 1934: Rec. Aust. Mus., Vol. 19, p. 177.
Müller, J. and Troschel, F. H., 1840: Arch. f. Naturgesch, Vol. 6: 1: pp. 318-326.
———— 1842: System der Asteriden, pp. 1-135.
———— 1843: Arch. f. Naturgesch, Vol. 9: 1: pp. 113-120.
———— 1844: Arch. f. Naturgesch, Vol. 10, p. 178.
Olsen, A. M., 1957: Aust. J. Mar. Freshw. Res., 8, pp. 392-409.
Perrier, E., 1875: Arch. Zool. exp., Vol. 4, p. 335.
———— 1876: Arch. Zool. exp., Vol. 5, p. 4.
———— 1894: Stell. 'Travailleur' et 'Talisman' p. 106.
Shepherd, S. A., 1967a: Rec. S. Aust. Mus., Vol. 16, p. 463.
———— 1967b: Trans. Roy. Soc. S.A., Vol. 91, p. 1.
Sladen, W. P., 1883: Jour. Linn. Soc. (Zool.), 17, pp. 214-269.
———— 1889: Challenger Ast., Vol. 30, pp. 1-893.
Verrill, A. E., 1913: Amer. Journ. Sci., 35, pp. 477-485.
———— 1914: Shallow water starfishes N. Pacific Coast, p. 363.
Wells, H. W., Wells, M. J., and Gray, I. E., 1961: Biol. Bull., 120: pp. 265-271.
Whitelegge, T., 1889: J. Roy. Soc. N.S.W., 23: pp. 163-323.
Womersley, H. B. S. and Edmonds, S. J., 1958: Aust. J. Mar. Freshw. Res., 9, pp. 217-260.

SOME CAVE-DWELLING PSEUDOSCORPIONIDEA FROM AUSTRALIA AND NEW CALEDONIA

By M. BEIER*

SUMMARY

Eight species and subspecies of Australian and New Caledonian cave-dwelling Pseudoscorpionidea are treated and five of them are described as new: *Austrochthonius cavicola* (South Australia), *Morikawia troglophila* (New Caledonia), *Pseudotyrannochthonius hamiltonsmithi* (Victoria), *Protochelifer naracoortensis* (South Australia), and *Protochelifer cavernarum* ssp. *aitkeni* (West Australia). *Ideobisium antipodum* (Sim.) from New Caledonia is redescribed.

The paper is based on a small, but very interesting collection of cave-dwelling species, made by E. Hamilton-Smith, P. Aitken, B. P. Moore, G. Sinclair, and J. Davidson in several caves of Australia and New Caledonia. Most of the species are new to science, because the cavernicolous fauna of Australia is poorly known at the present time. The holotypes of the new species are in the South Australian Museum, Adelaide, the paratypes in the Biospeological Collection of the same Museum and in the Museum of Natural History, Vienna.

Sathrochthonius tuena Chamberlin, 1962

Two nymphs, Punchbowl Cave, Wee Jasper, N.S.Wales, 22.VI.1963, B. P. Moore (BS0407), belong probably to this species, and many ♂♂ and ♀♀, Southern Limestone Cave, Jenolan, N.S.Wales species, *ex* Guano, 3.IX.1967, B. Dew *leg.*

Austrochthonius cavicola, sp. nov.

Fig. 1

Pale brownish yellow, chelicerae somewhat darker. Carapace as long as broad suborally, smooth, but reticulate in the hind corners and along the posterior border, with 18 bristles of approximately the same length, of which 6 are on the oral border and 2 on the posterior border; anterior border near the epistome, and epistome itself very roughly dentate, the epistome broken up almost entirely by these long and acute teeth. Eyes and eye-pigment absolutely wanting. Abdominal tergites 1 to 4 each with 4, those following with 6 bristles. Ultimate tergite with a pair of long tactile bristles. Palm of chelicerae with 5 bristles. Fixed cheliceral finger with about 8 teeth, movable one finely toothed, male without spinneret hump. Palpal femur a little longer than carapace, smooth. Hand narrow, 1.8 times as long as

* Naturhistorisches Museum, Burgring 7, Wien 1, Austria.

broad, sharply granulate dorsally. Chela 5.2 times longer than broad. Fingers 1.8 times longer than hand, straight, very densely toothed, the teeth obliquely truncate terminally. Fixed finger with about 60 teeth. Teeth of the movable finger smaller than those of the fixed one. Tactile seta *sb* of the movable finger nearly twice as far from *b* as from *st,* which is also twice as far from *sb* as from *t*. Coxae of first pair of legs broadly rounded orally and with two short bristles. Coxae of the second pair of legs with 4-5 finely dentate coxal spines. Intercoxal tubercle wanting. Genital opening of the male with 7 marginal bristles on each side.

Body: length ♂ 1.2 mm.

Carapace: length and breadth 0.37 mm.

Pedipalps: length femur 0.40 mm.; length hand 0.24 mm.; breadth hand 0.13 mm.; length fingers 0.44 mm.

Holotype—1 ♂, Cathedral Cave, Naracoorte, S. Australia, 1.IX.1962, E. Hamilton-Smith, dep. S. Austral. Mus. N196828.

This new cavernicolous species differs from the related *A. australis* Hoff by the absence of eyes, the absence of the two short lateral bristles on the posterior border of carapace, the shape of the epistome, the chaetotaxy of 4th tergal sclerite, the relatively slender chela and hand of pedipalps, more teeth on the fixed palpal finger, and fewer coxal spines.

Morikawia troglophila, sp. nov.

Fig. 2

Chelicerae intensively reddish brown, carapace and abdominal tergites olive-brown, pedipalps pale reddish yellowish-brown. Carapace scarcely shorter than broad anteriorly, strongly narrowed caudally, and neck-shaped constricted basally, smooth, but reticulate basally; with 16 long bristles and a pair of small preocular bristles; two of the anterior border bristles stand at the base of the epistome, the others before the eyes; two bristles on the posterior border. Epistomal process big and broad, tongue-shaped, narrowed distally, rounded terminally, and irregularly garnished with some fine prickles. Anterior eyes small, with their lens vaulted, posterior eyes reduced to pale spots. The two anterior abdominal tergites desclerotized, with the exception of a narrow transverse clasp, and finely transversely reticulate, the others smooth. Tergites 1-4 with 4, those following with 6 bristles. Ultimate tergite with 2 tactile bristles. Palm of chelicerae with 5 bristles and with fine prickles medially. Fixed cheliceral finger with a big tooth subapically, and with a row of small teeth proximally. Movable finger finely denticulate, without spinneret hump. Palpal femur about as long as carapace, smooth, with a row of 5 bristles medially, which gradually increase in length distally,

and with a long bristle dorsodistally. Hand relatively stout, 1.6 times longer than broad, with a single split-bristle mediodistally, which is comparatively short and reaches only to ¼the length of the fingers. Chela 4.8 times longer than broad. Fingers twice as long as hand. Fixed finger with 16 rather short and broad triangular teeth, which are somewhat retroclinate, and with similar, but much smaller intercalary teeth. Movable finger with 8 similar teeth in the distal half and also with small intercalary teeth, and with a serrate or undulate lamina in the proximal half. Tactile setae in common position, *sb* of the movable finger halfway between *b* and *st*. Coxae of the first pair of legs with a stout digitate process orally, which bears a small bristle subapically. Coxae of the second pair of legs with a row of 6 broad and flat coxal spines, which are fringed terminally. Coxae of third pair of legs with 4, those of fourth pair with 3, discal bristles and with a longer apical bristle. Intercoxal tubercle wanting.

Body: length ♀ 1.1 mm.

Carapace: length 0.37 mm., breadth anteriorly 0.40 mm., posteriorly 0.27 mm.

Pedipalps: length femur 0.37 mm.; length hand 0.21 mm., breadth hand 0.13 mm.; length fingers 0.42 mm.

Holotype—1 ♀ Grotte de Ninrin-Reu, near Poya, New Caledonia, 26.XII.1965, E. Hamilton-Smith, dep. S. Austral. Mus., N196829.

The new species, which is, probably only trogloxenous, is well distinguished from *M. zonata* Beier from the same island by the smaller body, by the big and broad epistome, which is terminally rounded and garnished with some fine prickles, by the much shorter palpal hand, which bears a single relatively short split-bristle mediodistally, by the much longer fingers, and by the less numerous coxal spines.

Pseudotyrannochthonius hamiltonsmithi, sp. nov.

Fig. 3

Carapace and abdominal tergites olive-brown, chelicerae and pedipalps pale reddish brown. Carapace a little broader than long, moderately narrowed caudally, densely alveolarly reticulate everywhere, with 14 long bristles and a pair of small and short preocular and mediolateral bristles respectively, the anterior border with 4, the posterior border with 2 bristles. Epistomal process prominent, broadly rounded, broader than long, thoroughly and densely covered with short prickles. Both pairs of eyes with vaulted lens. Abdominal tergites distinctly transversely reticulate. First tergite with 2, second and third with 4, fourth with 4 long and 2 short (lateral) bristles, the following tergites with 6 bristles of equal length. Ultimate

tergite without tactile bristles. Chaetotaxy of sternites irregularly, 9th and 10th sternite with 2 or 4 longer bristles, ultimate sternite with 2 bristles. Palm of chelicerae with 8 bristles, of which are the both lateral bristles very fine and short. Fixed cheliceral finger with 3 big teeth near the middle, and finely denticulate proximally. Movable finger with about one dozen denticles, the basal ones smaller, without spinneret hump. Palpal femur about 1.4 times longer than carapace, finely reticulate. Hand reticulate, 1.7 times as long as broad, weakly swollen dorsally. Tactile setae *ib* and *isb* situated dorsodistally, near the base of the fingers. Chela 5 times longer than broad. Fingers 1.8 times longer than hand, the fixed with about 20 mostly long and narrow, well spaced and erected teeth. Movable finger distally with 7-8 broadly triangular teeth, which are broader than long and shortly spaced, than with a shallowly serrate lamina. Tactile setae *sb*, *st*, and *t* of movable finger far distad, spaced nearly equidistantly, *sb* about 3 times further from *b* than from *t*. Coxae of first pair of legs with median corner boil-shaped, and with a row of 7-8 distally pennate coxal spines, which arise orally from an oblique ridge. Bisetose intercoxal tubercle present. Both tarsal joints of hind legs with a tactile bristle sub-basally.

Body: length ♀ 1.7-2 mm.

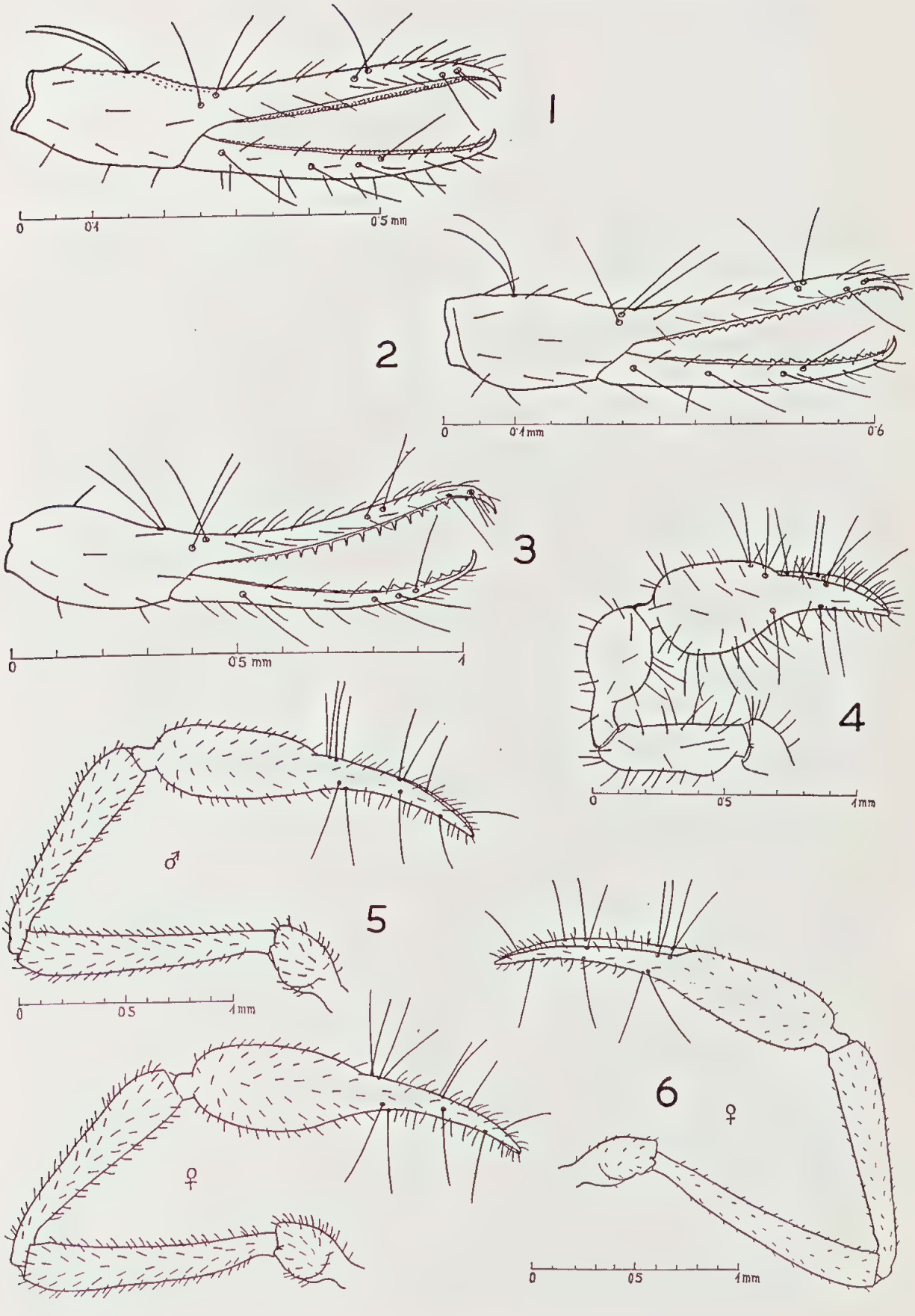
Carapace: length 0.51-0.52 mm., breadth 0.54-0.55 mm.

Pedipalps: length femur 0.74 mm.; length hand 0.38 mm., breadth hand 0.22 mm.; length fingers 0.70 mm.

Holotype—1 ♀ Mt. Widderin Cave, Skipton, Victoria, 16.XI.1964, E. Hamilton-Smith, dep. S. Austral. Mus. N196830.

The new species is closely related to *P. solitarius* (Hoff) and *P. bornemisszai* Beier, both from Victoria, but not cave-dwelling. It is easily recognizable by the presence of 7-8 very broad distal teeth of the movable palpal finger. *P. hamiltonsmithi* differs, moreover, from *solitarius* by the size being twice as big, the long and finely prickled epistome, fewer teeth of movable palpal finger, and more coxal spines, and from *bornemisszai* by smaller size, by the dentation of the fixed cheliceral finger, relatively longer palpal fingers, more teeth of movable palpal finger, and by the chaetotaxy of abdominal tergites 3 and 4.

Fig. 1. *Austrochthonius cavicola* sp. nov., ♂, chela laterally.
Fig. 2. *Morikawia troglophila* sp. nov., ♀, chela laterally.
Fig. 3. *Pseudotyrannochthonius hamiltonsmithi* sp. nov., ♀, chela laterally.
Fig. 4. *Ideobisium antipodum* (Sim.), ♂, left pedipalp.
Fig. 5. *Protochelifer naracoortensis* sp. nov., ♂ and ♀, left pedipalp.
Fig. 6. *Protochelifer cavernarum aitkeni* ssp. nov., ♀, right pedipalp.


1
0
0·1
0·5 mm
2
0
0·1 mm
0·6
3
0
0·5 mm
1
4
0
0·5
1 mm
♂
5
0
0·5
1 mm
♀
6
♀
0
0·5
1 mm

Ideobisium antipodum (Simon)

Fig. 4

Obisium antipodum Simon, 1880, Ann. Soc. ent. Belgique 23 CR: 174.

Ideobisium antipodum, Beier, 1932, Das Tierreich 57: 160.

One ♂, Grotte de Ninrin-Reu, near Poya, New Caledonia, 28.XII.1965, E. Hamilton-Smith (BS1310).

The single male specimen before me belongs certainly to this species described more than 80 years ago and since never recorded. The original description can be completed as follows:

Relatively big. Carapace and pedipalps intensively reddish brown, abdomen pale reddish yellowish-brown. Carapace a little longer than broad, smooth; its integument with an irregular and broad transverse zone of windows near the middle, a transverse row of small windows between the latter and the posterior border, which ends on both sides with a big window, and with a double longitudinal row of windows in the prozona; disc with 18 bristles, of which 4 are on the anterior and posterior border respectively; anterior border with a broad ridge roundly projecting orally. Eyes very close together, the anterior ones shallowly vaulted and about 1½ diameters distant from the anterior border, the posterior ones flat, but scarcely smaller. Abdominal tergites 1-4 and 10-11 each with 6, the others with 8 bristles. Ultimate tergite with tactile bristles laterally. Palm of chelicerae with 5 bristles, *ES* short. Fixed cheliceral finger finely and sharply denticulate, movable finger with 7 big teeth distally and 2 small denticles proximally. Galea long and slender, simple, slightly curved. Galeal bristle reaches the tip of the galea. Pedipalps robust, absolutely smooth. Femur very shortly and abruptly pedicellate, 3 times longer than broad, thickened laterobasally. Tibia 2.2 times longer than broad, with the pedicel slender and rather long and the club strongly swollen. Hand 1.6 times, chela with pedicel 2.9 times, without pedicel 2.7 times longer than broad. Fingers as long as hand without pedicel. Distribution of tactile setae as typical for the genus. Subterminal bristle of tarsi with a very fine denticle subapically.

Body: length ♂ 2 mm.

Carapace: length 0.56 mm., breadth 0.51 mm.

Pedipalps: length femur 0.58 mm., breadth femur 0.19 mm.; length tibia 0.55 mm., breadth tibia 0.25 mm.; length hand 0.55, breadth hand 0.34 mm.; length fingers 0.48 mm.

The species is distinguishable from *I. peregrinum* Chamberlin from New Zealand by the chaetotaxy of carapace, the better developed and contiguous eyes, stouter palpal joints, longer stalked tibia, longer fingers, and

almost simple subterminal bristle of tarsi. It differs from *I. pugil* Beier from the Solomon Islands by the much bigger size, the smooth palpal femur, and the longer fingers.

Protochelifer naracoortensis sp. nov.

Fig. 5

Carapace, pedipalps, and legs rather pale reddish-brown, abdominal tergites brownish. Integument very densely and uniformly granulate. Vestitural bristles relatively long in general, the dorsal bristles of body and the medial bristles of palpal trochanter and femur distinctly clavate, the others finely dentate apically. Carapace distinctly (nearly 1.3 times in the male) longer than broad, very densely granulate, without bigger granules, with the bristles clavate and dentate, rather short, but the anterior and posterior border bristles longer; both transverse furrows rather deep, the anterior one sharply incised, the sub-basal one more than twice as far from the anterior furrow as from the posterior border; the latter with 13-15 bristles; posterior corners not angulate in the male. Eyes well developed. Abdominal tergites densely transversely granulate, all divided in the female, the first undivided in the male, but without spines. Half tergites mostly with 9 posterior border bristles, the third (♀) or fourth (♂) and those following with an additional lateral border bristle. Ultimate tergite with about 10 marginal bristles, 2 discal bristles, and 2 rather short tactile bristles discally near the middle of each half tergite. The vestitural bristles distinctly clavate and gradually longer on the posterior segments. Sternal bristles acute, but dentate or slightly clavate on the posterior segments. Ultimate sternite with 2 short tactile bristles discally. Palm of chelicerae regularly with 5 acute bristles (occasionally with a supernumary bristle), *ES* very long, longer than *B* or *SB*. Galea almost simple in the male, with 5 acute apical branches in the female. Pedipalps very slender, densely and rather coarsely granulate, with numerous rather long bristles, which are distinctly clavate on the medial side of trochanter and femur, but dentate only elsewhere. Trochanteral humps round. Femur weakly pedicellate, gradually clavate distally, in the male 6-6.2 times, in the female 5.7-5.8 times longer than broad. Tibia also gradually clavate behind the short pedicel, broadest distally, 4.4-4.6 times longer than broad. Hand narrowly ovate, especially in the male, 2.2 times (♀)—2.6 times (♂), the whole chela with pedicel 4.3 times (♀)—5.1 times (♂), without pedicel 4 times (♀)—4.8 times (♂) longer than broad. Fingers as long as hand with pedicel or (♀) scarcely shorter. Disposition of tactile setae typically for the genus, *ist*, therefore, almost opposite *est* near the middle of the fixed finger, *it* far distally, *st* of the movable finger approaching *t*. Hind coxae of male densely setose medially, without coxal sacks, but with a pore, which bears a short membranaceous

tube. Ramshorn organs scarcely developed. Legs very slender, hind femur but slightly broadened proximally. Hind tarsi without tactile bristle. Subterminal bristle and claws simple.

Body: length ♂ 2.7 mm., ♀ 3.3-3.4 mm.

Carapace: length male 0.95 mm., female 0.98 mm.; breadth male 0.75 mm., female 0.85 mm.

Pedipalps: length femur male and female 1.20 mm., breadth femur male 0.20 mm., female 0.21 mm.; length tibia male 1.06 mm., female 1.11 mm., breadth tibia male 0.23 mm., female 0.25 mm.; length hand male 0.85 mm., female 0.89 mm., breadth hand male 0.33 mm., female 0.40 mm.; length fingers male and female 0.85 mm.

Holo- and allotype: 1 ♂, 1 ♀, Bat Cave, Naracoorte, S. Australia, 16.VI.1962, E. Hamilton-Smith, dep. S. Austral. Mus., N196831 and 32.

Paratypes: 12 ♂, 5 ♀, 6 nymphs, Bat Cave, Naracoorte, 5.XI.1961, 16.II., 16.VI., and 9.IX.1962, E. Hamilton-Smith (BSOO31, BSOO32, BSOO33, BSOO34, BSOO35, BSO197); 2 ♀, 2 nymphs, Bat Cave, Naracoorte, 5.VIII.1962, P. Aitken (BSO246).

The new species is closely related to *P. cavernarum* Beier from N.S.Wales, Victoria, and W. Australia and agrees with it in the clavate tergal bristles. It differs, however, from the latter in the relatively longer carapace, which does not bear larger granules, in the somewhat less slender pedipalps, and in the much longer, thicker, and stronger clavate medial vestitural bristles of pedipalps.

Protochelifer cavernarum Beier

2 ♂, Cliefden Caves, N.S.Wales, 27.I.1963, J. Davidson (BSO240); 2♂, 3 ♀, 3 nymphs, Ashford Cave, N.S.Wales, 1963 and 8.II.1964, K. Angel and E. Hamilton-Smith (BSO509 and BSO505); 1 ♂, 2 nymphs, Clogg's Cave, East Buchan, Victoria, 24.XI.1962 and 13.IV.1963, E. Hamilton-Smith and G. Sinclair (BSO167 and BSO318); 1 ♂, 3♀, 13 nymphs, Gooseberry Cave, Jurien Bay. W. Australia, 11.I.1965, E. Hamilton-Smith (BSO878).

This species was hitherto only known from N.S.Wales.

Protochelifer cavernarum ssp. **aitkeni** nov.

Fig. 6

Carapace and pedipalps pale reddish brown, abdominal tergites yellowish brown. Carapace and pedipalps, the hand inclusively, very densely granulate, abdominal tergites finer squamosely sculpturate. Vestitural bristles short and relatively sparse, the dorsal bristles of the body

dentate and slightly clavate, the medial bristles of pedipalps blunt and with a subapical denticle, the lateral bristles of pedipalps shorter, very thin, and acute. Carapace 1.2 times (♀) to 1.3 times (♂) as long as broad basally, slightly narrowed orally; the submedian transverse furrow sharply incised and deep, the subbasal one shallower, granulate, and more than twice as far from the anterior furrow as from the posterior border; hind corners simple in the male. Eyes with lens flatly vaulted. All abdominal tergites divided. Half tergites of the two anterior segments each with 6 marginal bristles, the others mostly with 5 posterior border bristles and 1 lateral border bristle, without median border or discal bristles. Half tergites of ultimate segment with 4 marginal bristles, of which the second one from the median line a moderately long tactile bristle. Ultimate sternite with short tactile bristles in the same position. The other sternites mostly with 6 acute posterior border bristles. Palm of chelicerae with 5 acute bristles, *ES* longer than *B* or *SB*. Galea with 3 terminal and 1 subapical branches. Galeal bristle reaches almost to the end of the galea. Pedipalps very slender. Trochanteral humps flatly rounded. Femur indistinctly pedicellate, gradually broadened to the end, broadest distally, 6.2-7 times, tibia 5-5.4 times, hand 2.7-2.8 times, chela with pedicel 5.3-5.7 times, without pedicel 5-5.4 times longer than broad. Fingers as long as hand with pedicel or but a little longer. Disposition of tactile setae as in the nominate form. Tibia of fore legs straight.

Body: length ♀ 2.5-3 mm.

Carapace: length 0.98-1 mm., breadth 0.75-0.85 mm.

Pedipalps: femur length 1.18-1.22 mm., breadth 0.18-0.19 mm.; tibia length 1.12-1.13 mm., breadth 0.21-0.22 mm.; hand length 0.88-0.91 mm., breadth 0.31-0.33 mm.; fingers length 0.89-0.95 mm.

Holotype: 1 ♀, Abrakurrie Cave, Nullarbor Plain, W. Australia, 13.I.1964, P. Aitken, dep. S. Austral. Mus., N196838.

Paratypes: 2 ♀, 1 Tritonymph from the same locality.

Differs from *cavernarum* s. str. in the smaller size, less numerous tergal bristles, the flat trochanteral humps, and the straight tibiae of the fore legs.

CATALOGUE OF METEORITES IN THE SOUTH AUSTRALIAN MUSEUM

(Excluding Tektites)

By DAVID W. P. CORBETT, Hon. Associate in Mineralogy,
South Australian Museum

INTRODUCTION

The South Australian Museum houses the largest collection of meteorites in the State—90 separate finds and falls are represented, including 26 main masses. No catalogue of the collection has previously been published. The only other important collection in South Australia is held by the Museum of the Geology Department of the University of Adelaide.

FIG. 1.
A section of the meteorite display at the South Australian Museum.

A third extensive collection, formerly in the private museum at Kyancutta on Eyre Peninsula, is now in the Australian National University, Canberra.

The first meteorite recorded at the Museum was a polished slice of the Barratta (N.S.W.) aerolite, acquired by exchange in 1852. The second acquisition was the Yardea iron, found in 1875 by James Martlew. This was the first meteorite found in South Australia. Further discoveries followed—the Rhine Villa iron in 1900 and the Murnpeowie iron in 1909. The main mass of the Rhine Villa was sent to Germany, but the Museum obtained a small slice. The Murnpeowie (the State's largest meteorite) was transferred to the Museum in 1963 from the South Australian School of Mines, where it had been on display for many years.

In 1908 Douglas Mawson (later Sir Douglas Mawson), Professor of Geology and Mineralogy at the University of Adelaide, began his long association with the Museum as Honorary Curator of Minerals, and the steady growth of the meteorite collection was in large measure due to his efforts. By 1914 the nucleus of the collection had been formed with the addition of the Arltunga iron (1908) and three stones, the Cadell (1910), Kulnine (1911) and the Carraweena (1914). Over a period of nearly 50 years he was successful in acquiring for the Museum almost all new meteorite discoveries within the State.

Probably the most significant additions were made following discoveries during the 1930's—a very active period in meteorite research in South Australia. The fall of the Karoonda meteorite in November, 1930, aroused widespread general interest as well as adding a chondrite of unique character to the State collection. As a direct result of the publicity over the Karoonda fall, the Museum commissioned A. R. Alderman (who later succeeded Mawson as Professor of Geology and Mineralogy at the University) to investigate a report of crater-like depressions at Henbury in the Northern Territory. Alderman's discovery of the Henbury Craters and associated iron masses created world-wide interest, and the results of his survey made an important contribution to the theory of crater formation.

Dr. C. T. Madigan, during one of his many expeditions to Central Australia, discovered the Boxhole Crater in 1937, and collected meteoritic iron from the area. A few weeks later he found the Huckitta stony-iron meteorite only 40 miles to the north-east of Boxhole. It is the largest pallasite so far discovered.

In 1953 Dr. W. Cassidy, of the University of New Mexico, came to South Australia as a Fulbright Scholar, and during a two-year association with the Museum, studied our meteorite and tektite collections and organized a meteorite display in the public gallery. Together with G. F. Gross of the Museum staff, he made an extensive field trip to the

Wolf Creek Crater in Western Australia and brought back over 1,000 lb. weight of iron shale balls. He also visited the Boxhole and Henbury craters, and collected impactites from the latter. Under Cassidy's direction, a large saw for cutting meteorites was designed and constructed by Mr. A. Rau of the Preparatorial Staff in 1954, and has proved of great value in slicing the larger meteorites.

Before leaving the Museum, Cassidy compiled information on all meteorites then in the collection with a view to publication. This work was continued by Dr. Brian Daily while Curator of Fossils and Minerals. The present author is greatly indebted to these two workers for much of the information in this catalogue.

The Museum has been fortunate in that many of its acquisitions, particularly in recent years, have been presented by the finders with no thought of financial gain. Quite outstanding amongst meteorite collectors is J. E. Johnson of the Geological Survey of South Australia. During many years of outback prospecting he has picked up five meteorites in widely separated parts of the State. All have been donated to State collections. The discoveries of Mrs. B. McDonald of Murray Bridge demonstrate the value of the keen amateur collector with an eye for the unusual. Within the space of a few months she found five separate stones—representing two distinct falls—in remote sand-dune country in the south-east of the State. The latest acquisition (at the time of writing) is a stone from Ki Ki in the Upper South-East, found in January, 1967, by R. Goodall, and presented by him to the Museum. This meteorite has proved to be part of the Coomandook fall first discovered in 1939.

CATALOGUE

Australian meteorites represented in the collection are listed alphabetically according to States. For each meteorite the name, with synonyms, is given, together with co-ordinates, stating where these are approximate only. The classification of the meteorite is followed by particulars of the find, including geographical location, the total weight and details of material housed in the collection. Published references are listed for all South Australian meteorites, and also where the main mass of an interstate find is held by the S.A. Museum. Foreign meteorites are dealt with less fully, and no details of occurrences are given.

In several instances it has been found that published co-ordinates for certain South Australian meteorites do not agree with the given geographical location. In these cases it has been assumed that the location is correct and the co-ordinates have been recalculated. The corrected co-ordinates are given together with those appearing in the 3rd Edition of Hey's Catalogue of Meteorites, 1966.

Where weights were originally recorded in British units, these are given together with a conversion to the metric scale. All new weights are recorded in metric units only.

A considerable amount of unpublished data is incorporated in this catalogue (see acknowledgments).

Classification

The classification used in this catalogue follows that of Hey in the 3rd Edition of the "Catalogue of Meteorites", 1966, British Museum, London, with certain minor modifications.

Irons (Siderites)

Nickel-rich ataxites
Octahedrites (fine, medium and coarse)
Hexahedrites
Metabolites

Stony-irons (Siderolites)

Pallasites
Siderophyres*
Lodranites*
Mesosiderites

Stones (Aerolites)

Enstatite chondrites
Olivine-bronzite chondrites
Olivine-hypersthene chondrites
Olivine-pigeonite chondrites
Carbonaceous chondrites*
Enstatite achondrites*
Hypersthene achondrites
Olivine achondrites*
Olivine-pigeonite achondrites*
Diopside-olivine achondrites*
Augite achondrites*
Pyroxene-plagioclase achondrites

* Not represented in the S.A.M. collection.

The South Australian Museum holds the following main masses:—

South Australia

Accalana
Cadell
Carraweena
Cocunda
Coomandook
Coonana
Crockers Well
Karoonda
Kaldoonera Hill
Lake Bonney
Murnpeowie
Nora Creina
Vincent
Wilbia
Yardea

Northern Territory

Alikatnima
Arltunga
Boxhole
Huckitta
Mt. Sir Charles

Other States

Cartoonkana (N.S.W.)
Yandama (N.S.W.)
Dimboola (Vic.)
Kulnine (Vic.)
Lake Grace (W.A.)
Wingellina (W.A.)

South Australian Meteorites

At the time of writing 30 meteorites have been recorded from South Australia. They may be grouped as follows:—

	Finds	Falls	Total
Iron	7	—	7
Stony-iron	1	—	1
Stone	21	1	22
Total	29	1	30

This table includes the Forrest Lakes chondrite, which would seem to be a South Australian find (McCall and de Laeter, 1965). Accalana and Carraweena are considered a paired fall, but are tabled as separate finds (Mason and Wiik, 1966). The Glen Osborne Meteorite has been discredited by Alderman (1936) and is not included.

The main masses of 15 of these 30 meteorites are held by the S.A. Museum (See List p. 770). Other main masses are distributed as follows:—

University of Adelaide, Geology Department Museum—
Artracoona, Cowell, Kielpa, Moorumbunna, Pinnaroo* and *Witchellina** 6

Australian National University, Canberra—
Kyancutta and *Lake Labyrinth* 2

South Australian Geological Survey—
Monte Colina 1

National Museum of Victoria—
Caroline 1

Australian Museum, Sydney—
*Weekeroo** 1

Government Chemical Laboratories, Perth—
*Forrest Lakes** 1

Unknown—*Rhine Villa, Kingoonya* and *Kappakoola** . . . 3

15

* Not represented in the S.A.M. Collection

SOUTH AUSTRALIAN METEORITES

ACCALANA 29° 15′ S, 139° 59′ E

Stone, olivine-hypersthene chondrite.

Found prior to 1917. Purchased from C. Schunke in 1925.

Total Weight: 6 lb. 8oz. (2.94 kg.). One mass.

S.A.M. Collection: *Main mass*
G5665 5 lb. 8oz. (2.50 kg.).

Remarks: Accalana is now considered to be part of the same fall as Carraweena.

References:
Spencer, L. J., 1935. Min. Mag., 24 (148), p. 14.
Spencer, L. J., 1936. Min. Mag., 24 (154), p. 361.
Alderman, A. R., 1936. Rec. S. Aust. Mus., 5, p. 537.
Mason, B., and Wiik, H. B., 1966. Am. Mus. Novit. 2273.

ARTRACOONA 29° 04′ S, 140° 00′ E

Stone, olivine-hypersthene chondrite.

Found 1914, by G. Amesbury, on the Carraweena run 8 miles north-west of the old Carraweena Head Station, and 6 miles west of Artracoona Hill.

Total Weight: 45 lb. 14oz. (20.81 kg.). One mass. *Main mass* in the University of Adelaide Collection.

S.A.M. Collection: G7940 502 gm.

Reference:
Kleeman, A. W., 1936. Trans. R. Soc. S. Aust., 60, p. 73.

CADELL 34° 04′ S, 139° 45′ E

Stone, olivine-hypersthene chondrite.

Found 1910, by C. H. Bannear, 3 miles from Morgan, Hundred of Cadell, South Australia, on the east side of the Murray River. Presented to the S.A. Museum by C. H. Bannear.

Total Weight: 7 lb. 4oz. (3.2 kg.). One mass.

S.A.M. Collection: *Main mass*
G5666A 5 lb. (2.27 kg.).
G5666B 1 lb. 2¾oz. (538 gm.).

References:
Anderson, C., 1913. Rec. Aust. Mus., 10, p. 57.
Alderman, A. R., 1936. Rec. S. Aust. Mus., 5, p. 537.

CAROLINE 38° 00′ S, 140° 55′ E

Stone, olivine-bronzite chondrite.

Found before 1941, by S. McEachern, on a native camp-site about 7 miles south of Caroline near the Glenelg River, South Australia.

Total Weight: 800 gm. One mass. *Main mass* in National Museum of Victoria, Melbourne.

S.A.M. Collection: G7715 33.5 gm.

Remarks: Stone highly weathered.

Reference:
Stillwell, F. L., 1941. Mem. Nat. Mus. Vict., 12, p. 41.

CARRAWEENA 29° 10′ S, 140° 00′ E

Stone, olivine-hypersthene chondrite.

Found 1914, by G. Amesbury, about 6 miles south-west of old Carraweena Station, north-east of South Australia.

Total Weight: 63 lb. 8oz. (28.8 kg.). One, almost complete, stone.

S.A.M. Collection: *Main mass*
G5691 48 lb. (21.77 kg.).
G5691A 3 lb. 4oz. (1.47 kg.).
G5691C 10½oz. (297 gm.).
G5691B 72 gm.

Remarks: Carraweena is now considered to be part of the same fall as Accalana.

References:
Alderman, A. R., 1936. Rec. S. Aust. Mus., 5, p. 537.
Mason, B., and Wiik, H. B., 1966. Am. Mus. Novit. 2273.

COCUNDA 32° 49′ S, 134° 48′ E

Stone, olivine-hypersthene chondrite.

Found 1945, by B. Polomka, three-quarters of a mile west of Cocunda Rocks, Eyre Peninsula, South Australia. Presented to the S.A. Museum by B. Polomka in 1946.

Total Weight: 1 lb. 1oz. (482 gm.). One mass.

S.A.M. Collection:

	Main Mass
G5988	14oz. (396.9 gm.).

COOMANDOOK Fig. 2B 35° 25′ S, 139° 45′ E
Recalculated 35° 29′ S, 139° 50′ E

Stone, olivine-bronzite chondrite.

Found 1939, by G. Ninnis, 8 miles due east of Coomandook, Section 21, Hundred of Roby. Presented to the S.A. Museum by G. Ninnes in 1940. A second stone, of 10 lb. weight, was found on a cleared paddock, 4¾ miles north-east of Ki Ki in January, 1967 by R. Goodall, and also presented to the S.A. Museum.

Total Weight: 11 lb. 8½oz. (5.23 kg.). Two masses.

S.A.M. Collection:

	Main Mass
G5996B	9 lb. 3½oz. (4.18 kg.).
G5996A	2 lb. (907.2 gm.).

Remarks: The two masses were both found on the surface when clearing stones. The site of the 1967 find is less than 10 miles from the original discovery. The stones are similar in external appearance and mineralogical composition (B. Mason, pers. com.).

COONANA 29° 20′ S, 140° 45′ E
Recalculated 29° 51′ S, 140° 45′ E

Stone, olivine-bronzite chondrite.

Found 1962 by J. Rattus in sand dunes 3½ miles west of Coonana bore, north-eastern South Australia.

Total Weight: 15 lb. (6.80kg.). One shattered mass. One-fifth of the stone was not collected.

S.A.M. Collection:

	Main Mass
G7417A	9 lb. 9½oz. (4.36 kg.).
G7417B	15oz. (425.2 gm.).
G7417C	54.5 gm.

Remarks: Oxidized condition of stone suggests a fall of some antiquity.

COWELL 33° 20′ S, 130° 03′ E

Iron, medium octahedrite.

Found 1955, 30 miles north-west of Cleve, Eyre Peninsula. *Main mass* in University of Adelaide Collection.

Total Weight: 5.72 kg.

S.A.M. Collection: G7944 128 gm. Slice in plastic.

CROCKER'S WELL 32° 01′ S, 139° 47′ E

Stone, chondrite (unclassified).

Found 1956, by J. E. Johnson, on a granite hill one-quarter of a mile north of East Crocker uranium prospect. Presented by J. E. Johnson, 1956.

Total Weight: 3.8 gm. Only one fragment found.

S.A.M. Collection:

	Main Mass
G5909	3.8 gm.

KALDOONERA HILL 32° 30′ S, 134° 57′ E

Stone, olivine bronzite chondrite.

Found prior to 1956, on the property of Mr. Voumard near Kaldoonera Hill, Eyre Peninsula, South Australia. Acquired by the S.A. Museum from Mr. Beck, Poochera, South Australia.

Total Weight: 16 lb. 8oz. (7.49 kg.). Two masses.

S.A.M. Collection: *Main mass*
G5910A 10 lb. (4.54 kg.).
G5910B 4 lb. 1½oz. (1.86 kg.).

Remarks: The finder reports that the plough occasionally strikes rock, which could indicate further meteorite pieces, as there is no solid rock in the area other than the surface travertine limestone (kunkar).

KAROONDA Fig. 3B 35° 07′ S, 139° 53′ E
Recalculated 35° 06′ S, 139° 56′ E

Stone, olivine-pigeonite chondrite.

Fell 1930, at 10.53 p.m. on 25 November. Found in sandy, fallowed wheat field, 2¼ miles east of Karoonda, South Australia. Material presented to the S.A. Museum by Professor Kerr Grant. The fall was preceded by a brilliant fireball seen over a radius of 250 miles.

Total Weight: 92 lb. (41.73 kg.). Numerous fragments. Mass shattered on impact.

S.A.M. Collection: *Main mass*
G5674A 7 lb. 12oz. (3.51 kg.).
G5674B 4 lb. 7oz. (2.00 kg.).
Plus fragments of under 1 lb. weight. Total weight 879 gm.

Remarks: Karoonda is unusual in containing no metallic phase, suggesting links with the carbonaceous chondrites. It does not contain carbon or organic compounds. The principal sulphide phase is pentlandite.

References:
Grant, K., and Dodwell, G. F., 1931. Nature, 127, pp. 402-403 and 631.
Mawson, D., 1934. Trans. R. Soc. S. Aust., 58, p. 1.
Wahl, W., 1950. Geochim. et Cosmochin. Acta 1, p. 28.
Mason, B., and Wiik, H. B., 1962. Am. Mus. Novit., 2115.

KINGOONYA (Synonym—Kingooya) 30° 57′ S, 135° 20′ E

Stone, olivine-hypersthene chondrite.

Found 1927, near 204-mile peg, on Transcontinental Railway, Nullarbor Plain, South Australia. Co-ordinates place it 4 miles south-east of Kingoonya.

Total Weight: About 6 lb. (2.7 kg.). Location of *main mass* unknown.

S.A.M. Collection: G6074 87 gm.

Remarks: The stone was broken into three pieces by the finders and sent to S. F. C. Cook in Kalgoorlie, Western Australia. The S.A. Museum specimen was acquired as part of the Cook Collection of Minerals in 1945. Formerly believed to be identical with Lake Labyrinth. Now shown to be a separate fall by B. Mason (pers. com.).

Reference:
Spencer, L. J., 1936. Min. Mag. 24 (154), p. 361.

KYANCUTTA 33° 10′ S, 135° 25′ E
Recalculated 33° 17′ S, 136° 00′ E

Iron, medium octahedrite.

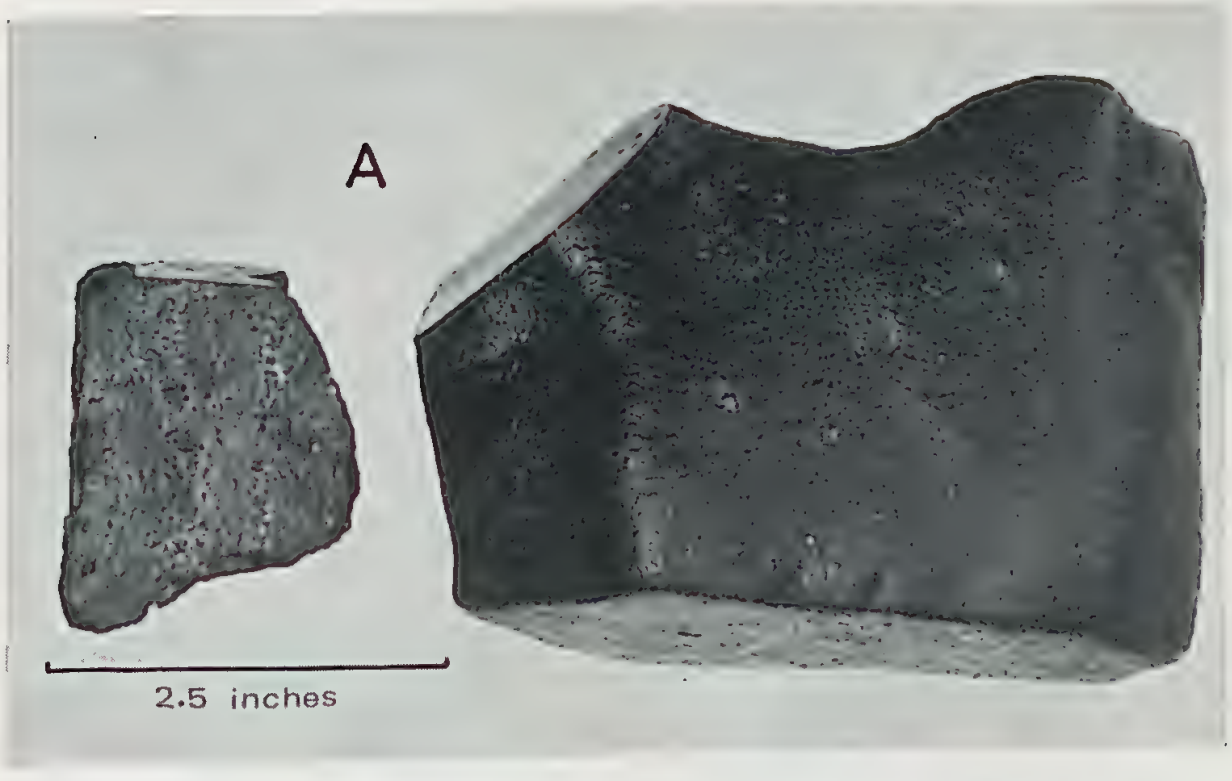
Found 1932, by L. G. Gardiner, in a sandy paddock 28 miles east-south-east of Kyancutta.

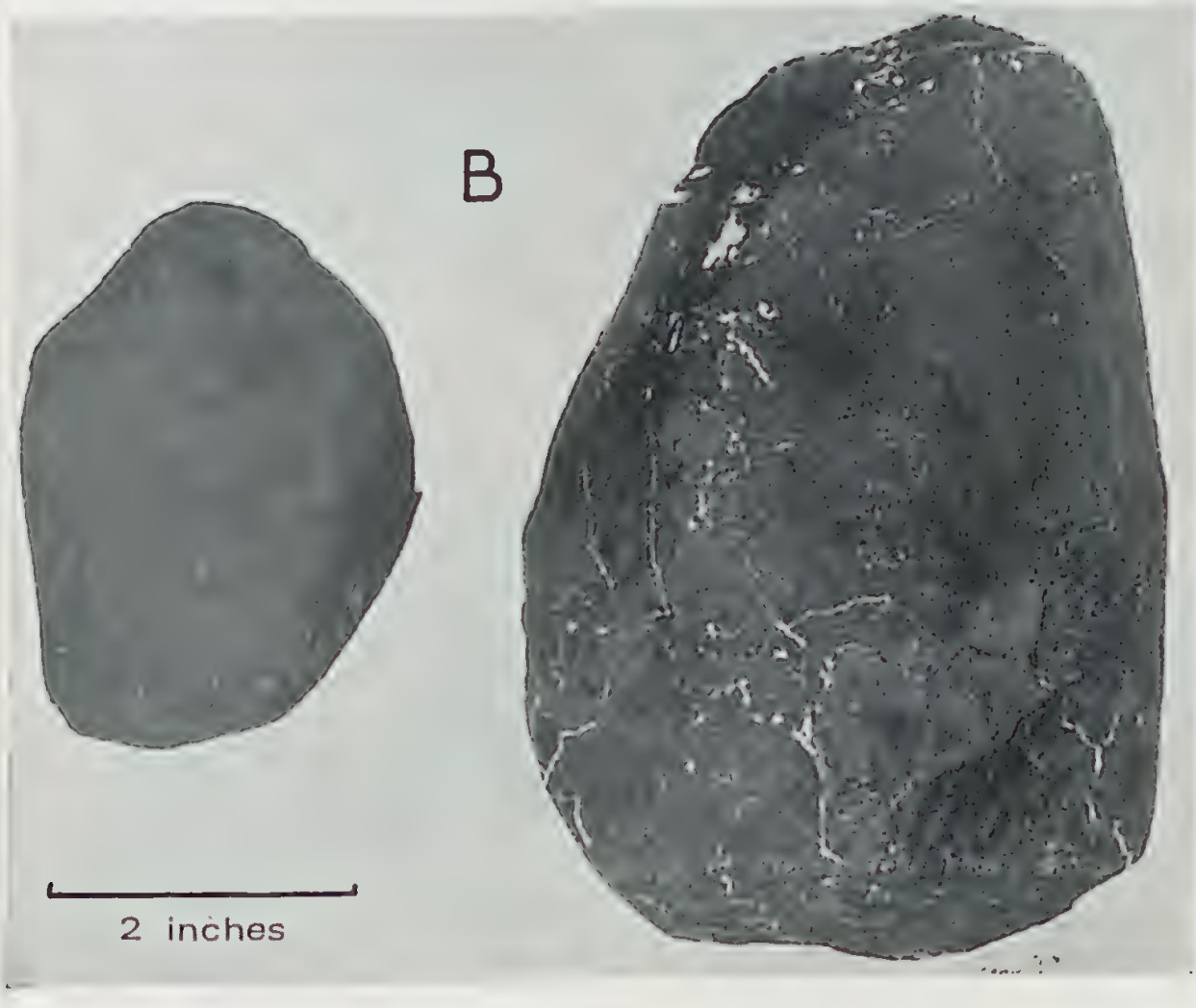
Total Weight: 72 lb. (32.6 kg.). One mass. *Main mass* in Australian National University, Canberra.

FIG. 2.

A. Left: The main mass of the Nora Creina meteorite. Right: The main mass of the Lake Bonney meteorite.

B. The two stones of the Coomandook find. The original (1939) discovery is shown on the left and the 1967 find on the right.


A
2.5 inches


B
2 inches

S.A.M. Collection: G5682 1 lb. 14oz. (850.5 gm.).

Reference:
Spencer, L. J., 1933. Min. Mag. 23 (140), p. 329.

LAKE BONNEY (Fig. 2A (part)) 37° 45′ S, 140° 18′ E

Stone, olivine-hypersthene chondrite.

Found 1961, by Mrs. B. G. McDonald, near Jacky Point, Lake Bonney, south-east of South Australia. A total of four masses were found in 1961 and 1962 by Mrs. McDonald. The main mass and two other stones were presented to the S.A. Museum by the finder in 1962.

Total Weight: 2.75 kg., in four masses.

S.A.M. Collection:

	Main mass
G7345	1.96 kg.
G7346	517 gm.
G7347	56.70 gm.

Remarks: A stony meteorite found 42 miles to the north-west of Jacky Point in 1962 was included in the Lake Bonney group, but is a separate fall. (See Nora Creina.)

References:
Corbett, D. W. P., 1964. Rec. S. Aust. Mus., 14 (4), p. 695.
Corbett, D. W. P., 1967. Min. Mag. 36 (278), p. 293.

LAKE LABYRINTH 30° 20′ S, 134° 45′ E
Recalculated 30° 32′ S, 134° 45′ E

Stone, olivine hypersthene chondrite.

Found 1924, by Billy Austin, a fortnight after the probable fall, 8 miles north of Peela Well, Wilgena Station, South Australia. (16 miles N.N.E. of Tarcoola.) Collected by R. Bedford, 1934.

Total Weight: About 57 lb. (25.85 kg.). *Main mass* in Australian National University, Canberra.

S.A.M. Collection: G5681 3 lb. 5½oz. (1.5 kg.).

Reference:
Spencer, L. J., 1936. Min. Mag. 24 (154), p. 353.

MONTE COLINA 29° 24′ S, 139° 59′ E approx.

Stone, olivine-hypersthene chondrite.

No details of the discovery are known. The *main mass* is in the collection of the South Australian Department of Mines, Adelaide.

Total Weight: 116.8 gm.

S.A.M. Collection: G7941 10 gm.

Remarks: Probably same fall as Accalana and Carraweena.

Reference:
Mason, B., and Wiik, H. B., 1966. Am. Mus. Novit. 2273.

MOORUMBUNNA 28° 55′ S, 136° 14′ E

Iron, medium octahedrite.

Found 1943, 7¼ miles due west of William Creek Railway Station, South Australia. Presented to the University of Adelaide by G. K. G. Warren.

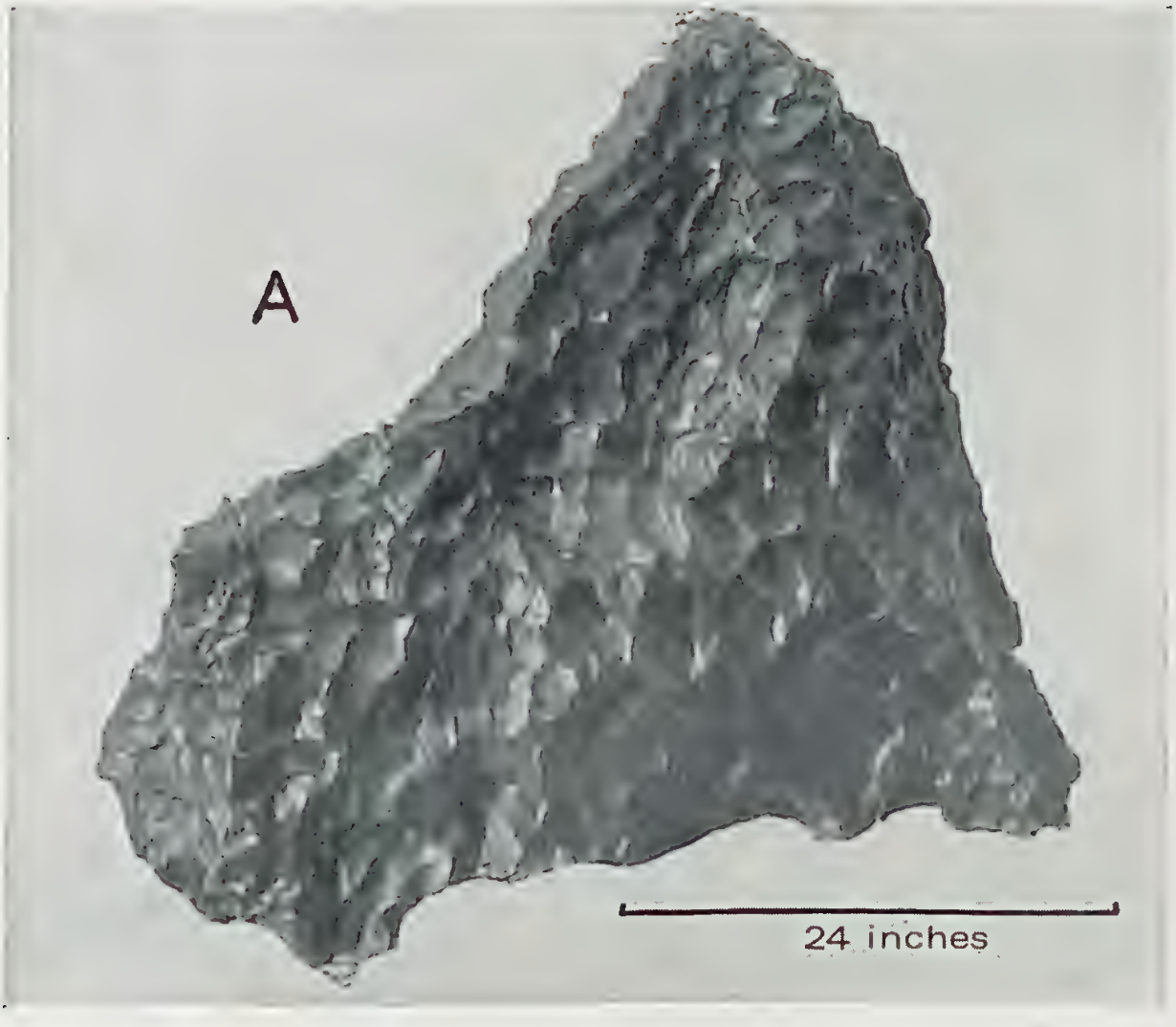
Total Weight: 169 lb. 14oz. (77 kg.). *Main mass* in the University of Adelaide Collection.

S.A.M. Collection: G7942 584 gm. Slice.

Reference:
Edwards, A. B., 1946. Trans. R. Soc. S. Aust., 70 (2), p. 348.

FIG. 3.

A. The Murnpeowie siderite.
B. The main mass of the Karoonda meteorite.


A
24 inches

B
5 inches

MURNPEOWIE Fig. 3A 29° 35′ S, 139° 54′ E

Iron, metabolite.

Found 1909, about 16 miles north-east by east of Mount Hopeless, South Australia. Presented to the S.A. School of Mines (now Institute of Technology). On permanent loan to the S.A. Museum.

Total Weight: Slightly over 2,520 lb. (1,143.1 kg.). One mass. A small portion has been cut off.

S.A.M. Collection: *Main mass*
G7956 2,520 lb. (1,143.1 kg.).

Remarks: Probably fell between 1905 and 1909—was in very fresh condition when found.

References:
Smith, L. L., 1910. Am. J. Sci., 30, p. 264.
Spencer, L. J., 1935. Min. Mag. 24 (148), p. 13.

NORA CREINA (Fig. 2A (part)) 37° 19′ S, 139° 51′ E

Stone, olivine-hypersthene chondrite.

Found 1962, by Mrs. B. G. McDonald of Millicent, at Nora Creina Bay, 12 miles south-south-east of Robe, South-East of South Australia. Presented to the S.A. Museum by Mrs. McDonald.

Total Weight: 283.5 gm. One mass.

S.A.M. Collection: *Main mass*
G7579 283.5 gm.

Remarks: Originally described as a member of the Lake Bonney fall, but subsequent work on the pyroxenes (B. Mason, pers. com.) shows it to be a separate fall.

References:
Corbett, D. W. P., 1964. Rec. S. Aust. Mus., 14 (4), p. 695.
Corbett, D. W. P., 1967. Min. Mag., 36 (278), p. 293.
Mason, B., 1967. Geochim. et Cosmochim. Acta, 31, p. 1100.

PINNAROO 35° 17′ S, 140° 55′ E
Recalculated 39° 19′ S, 141° 04′ E

Stony-iron, mesosiderite.

Found 1927, by Mr. S. Hamilton about 9 miles south-south-east of Pinnaroo.

Total Weight: 39.4 kg. *Main mass* in the University of Adelaide Collection.

S.A.M. Collection: G7943 61 gm.

Reference:
Alderman, A. R., 1940. Trans. R. Soc. S. Aust., 64, p. 109.

RHINE VILLA 34° 20′ S, 139° 10′ E

Iron, medium octahedrite.

Found 1900, by H. W. Payne, at Rhine Villa (now Cambrai), about 50 miles north-east of Adelaide.

Total Weight: 3.325 kg. *Main mass* sent to Germany.

S.A.M. Collection: G5672B 3oz. (85 gm.).

References:
Goyder, G. A., 1901. Trans. R. Soc. S. Aust., 25, p. 14.
S.A. School of Mines and Industries, Annual Report, 1900, p. 227.

VINCENT 35° 07′ S, 139° 53′ E

Stone, olivine-hypersthene chondrite.

Found 1926, approximately 6 miles N.N.E. of Karoonda, Section 34, Hundred of Vincent, South Australia. Presented by Mr. E. A. P. Hoff in 1956.

Total Weight: 15oz. (425.2 gm.). One mass.

S.A.M. Collection: *Main mass*
G5908 11¼oz. (318 gm.).

WILBIA 26° 27′ S, 131° 00′ E

Chondrite, unclassified.

Found May, 1965, by J. E. Johnson, on a sand dune at the east end of Wilbia Hill, Musgrave Ranges, South Australia.

Total Weight: 94 gm. One mass.

S.A.M. Collection:

	Main mass
G7902	94 gm.

YARDEA 32° 25′ S, 135° 30′ E
Recalculated 32° 27′ S, 135° 33′ E

Iron, medium octahedrite.

Found 1875, by J. Martlew, 4 miles south of Yardea Station, Gawler Ranges, South Australia.

Total Weight: 7 lb. 4oz. (3.29 kg.).

S.A.M. Collection:

	Main mass
G5673	6 lb. 4oz. (2.83 kg.).

Remarks: Originally slightly heavier, but a small piece was broken off prior to its arrival at the Museum.

References:

Cloud, T. C., 1883. Trans. R. Soc. S. Aust., 6, p. 82.
Anderson, C., 1913. Rec. Aust. Mus., 10, p. 66.

NORTHERN TERRITORY METEORITES

ALIKATNIMA 23° 20′ S, 134° 07′ E

Iron, nickel-rich ataxite.

Found 1931, about 45 miles north-north-east of Alice Springs, Northern Territory. Acquired by the S.A. Museum from B. Webb, Alice Springs.

Total Weight: Over 35 lb. (15.87 kg.). Believed to have been one mass originally.

S.A.M. Collection:

	Main mass
G5683A	20 lb. (9.07 kg.).
G5683B	12 lb. 12oz. (5.78 kg.). Originally 15 lb.
G5683C	145 gm. Slice.

Reference:

Alderman, A. R., 1936. Rec. S. Aust. Mus., 5, p. 537.

ARLTUNGA 23° 20′ S, 134° 40′ E

Iron, metabolite.

Found 1908, 2 miles north of the Government Cyanide Works, Arltunga goldfields, Northern Territory. Found by D. Pedler. Purchased by S.A. Museum from J. Woodford, 1908.

Total Weight: 40 lb. (18.14 kg.).

S.A.M. Collection:

	Main mass
G5692A	28 lb. (12.70 kg.).
G5692C	12½oz. (354.4 gm.). Slice.
G5692D	474 gm.

Remarks: A recent fall when discovered. Had ploughed a groove about 5ft. deep in soft ground.

References:

Smith, L. L., 1910. Am. J. Sci., 30, p. 264.
Anderson, C., 1913. Rec. Aust. Mus., 10, p. 54.
Mawson, D., 1934. Trans. R. Soc. S. Aust., 58, p. 1.
Edwards, A. B., 1943. Rec. Aust. Mus., 21, p. 154

BOXHOLE 22° 37′ S, 135° 12′ E

Iron, medium octahedrite.

Found 1937, associated with crater and shale-balls, three-quarters of a mile north of Boxhole Station, Plenty River, Northern Territory, 120 miles north-east of Alice Springs.

Total Weight: Unknown. It is believed that the 368 lb. iron in the S.A. Museum is the largest single mass of Boxhole ever found.

S.A.M. Collection:

Irons:
G5992A 368 lb. (166.92 kg.).
G6014 16 lb. 4oz. (7.37 kg.).
G6015 5 lb. 8oz. (2.49 kg.).
G5992D 1 lb. 8oz. (680.4 gm.).
G5992E 1 lb. 2oz. (510.3 gm.). Slice.
G6015A 460 gm.
Shale balls:
G6061A-D 1 lb. 7½oz. (661.4 gm.).

Remarks: The large iron mass was acquired by the S.A. Museum from the Webb Brothers, Mt. Riddock Station, Northern Territory, in 1949.

References:

Madigan, C. T., 1937. Trans. R. Soc. S. Aust., 61, p. 187.
Madigan, C. T., 1940. Min. Mag. 25 (168), p. 481.

HENBURY 24° 34′ S, 133° 10′ E

Iron, medium octahedrite.

Found 1931, by H. A. Ellis, 7 miles west-south-west of Henbury Station, Finke River, Northern Territory. Associated with craters and impactites.

Total Weight: Well over 910 kg. in numerous masses. Many pieces show distortion.

S.A.M. Collection:

Iron: 133 kg. 107 pieces, largest weighing 59 lb. (26.76 kg.).
Shale balls: 2.83 kg.
Impactite: 2.94 kg.
Silica glass: 18 gm.

References:

Alderman, A. R., 1932. Min. Mag. 23 (136), p. 19.
Alderman, A. R., 1932. Rec. S. Aust. Mus., 4, p. 555.
Spencer, L. J., 1933. Min. Mag. 23, p. 387.

HUCKITTA (Synonyms—Alice Springs, Huckitte) 22° 22′ S, 135° 46′ E

Stony-iron, pallasite.

Found 1937, by C. T. Madigan, approximately 20 miles north-east of Huckitta Station, north of Dulcie Range, Northern Territory. Presented to the S.A. Museum by W. Burdett, of Basket Range, South Australia, 1937.

Total Weight: Over 2 tons (2,032.1 kg.) surrounded by over 900 kg. of iron shale.

S.A.M. Collection:

Main mass
G6916A Approx. 1 ton (916 kg.).
G6916C 4cwt. (203 kg.).
G5990B 22 lb. (9.98 kg.).
G5990A 21 lb. (9.53 kg.).
G5990 4 lb. 2oz. (1.87 kg.).
G5990E 2 lb. ¾oz. (928 gm.).
The collection also includes 1,935 lb. (877 kg.) of iron shale, the largest piece weighing 287 lb. (130.18 kg.).

Remarks: A mass of 1,084 gm. found in 1924 near Alice Springs by H. Basedow, is believed to be a transported fragment of Huckitta.

References:

Spencer, L. J., 1932. Min. Mag. 23, p. 38.
Madigan, C. T., 1937. Trans. R. Soc. S. Aust., 61, p. 187.
Madigan, C. T., 1939. Min. Mag. 25, p. 353.

FIG. 4.
The Mount Sir Charles siderite.

MT. SIR CHARLES (formerly Bond Springs), Fig. 4 23° 50′ S, 134° 02′ E

Iron, fine octahedrite.

Found 1942, by T. Williams, 7 miles east of Bond Springs Station, Northern Territory. Acquired by the S.A. Museum through N. C. Bell, Alice Springs, in 1942.

Total Weight: 50 lb. 8oz. (22.91 kg.). A fragment of about 1 lb. was broken off the main mass after discovery and cannot be accounted for.

S.A.M. Collection: *Main mass*
G5994 49 lb. (22.23 kg.).

Remarks: The name Bond Springs, formerly given to this meteorite, has already been applied to a small chondrite found in the same area before 1898. (See Baker, G., and Edwards, A. B., 1941, Mem. Nat. Mus. Vict., 12, p. 49.)

TAWALLAH VALLEY 15° 42′ S, 135° 40′ E

Iron, nickel-rich ataxite.

Found 1939, about 48 miles north-west of Borroloola, Northern Territory.

Total Weight: 75.75 kg. *Main mass* in Australian Museum, Sydney.

S.A.M. Collection: G7945 552 gm. Slice.

WESTERN AUSTRALIAN METEORITES

COCKLEBIDDY 31° 55′ S, 126° 15′ E

Stone, olivine-bronzite chondrite.

Found 1949, 3 miles north of Nallah Nallah Rockhole, which is 10 miles east-north-east of Cocklebiddy on the Eyre Highway, Western Australia.

Total Weight: 19.5 kg. (43 lb.). *Main mass* in Western Australian Museum, Perth.

S.A.M. Collection: G7700 151 gm.

DALGARANGA 27° 43′ S, 117° 15′ E

Stony-iron, mesosiderite.

Found 1923, associated with crater and shale balls, on Dalgaranga Station, north of Yalgoo, Western Australia.

Total Weight: Over 1.09 kg. (207 masses plus fragments).

S.A.M. Collection: G7105 282 gm. Shale balls.

HAIG (Synonym—Rawlinna) 31° 30′ S, 125° 05′ E

Iron, medium octahedrite.

Found 1951, 36 miles south-south-west of Rawlinna, Western Australia, on the Trans-Australia Railway Line. Presented to the S.A. Museum by A. J. Carlisle, Rawlinna, W.A., in 1952.

Total Weight: 480 kg. (1,057 lb.). *Main mass* in the Western Australian Museum, Perth.

S.A.M. Collection: G5991 18 gm.

LAKE BROWN (Synonym—Burracoppin) 31° 00′ S, 118° 31′ E

Stone, olivine-hypersthene chondrite.

Found 1919, at Lake Brown, County Avon, South-west Division, Western Australia. Purchased with the H. G. Stokes collection of minerals.

Total Weight: 9.75 kg. Main mass in Western Australian Museum, Perth.

S.A.M. Collection: G6066 142 gm. (with fusion crust).

LAKE GRACE 33° 04′ S, 118° 13′ E

Stone, olivine-hypersthene chondrite.

Found 1956, by T. Griffin, 3 miles north-north-west of Tarin Rock Siding, Western Australia. Presented to the S.A. Museum by Mr. C. Griffin in 1959.

Total Weight: 10.5 kg. (23 lb. 2oz.). Originally one mass the size of a football, now fragmented.

S.A.M. Collection: *Main mass* 16 pieces plus fragments.
G6084A 1 lb. 15oz. (878.8 gm.).
G6084B 1 lb. (453.6 gm.).
G6084G 9 lb. 7½oz. (4.29 kg.).
G6084H 3 lb. 11oz. (1.67 kg.).
G6084I 1 lb. 3½oz. (552.8 gm.).
G6084K 3 lb. 1½oz. (1.40 kg.).
Plus nine pieces under 1 lb. in weight—total weight 487.7 gm.

WINGELLINA 26° 03′ S, 128° 57′ E

Stone, olivine-hypersthene chondrite.

Found 1958, by J. E. Johnson, on stony ground 4 miles south-west of the intersection of the South Australian, Western Australian and Northern Territory borders, north of the Hinckley Range, W.A. Presented by J. E. Johnson, 1959.

Total Weight: 200 gm. One mass.

S.A.M. Collection: Residue of *main mass*.
G6082 28.5 gm. (two fragments).

WOLF CREEK 19° 18′ S, 127° 46′ E

Iron, medium octahedrite.

Crater recognized in 1947 from the air. First visited in 1949.

Total Weight: Iron shale (shale balls) weighing several thousand kilograms in numerous masses has been collected from around the crater. In 1965 an A.N.U. party collected 1.3 kg. of nickel-iron fragments.

S.A.M. Collection: Iron—G7955 34 gm.
Shale ball—G5995 336 lb. (152.40 kg.).
The collection also includes numerous smaller masses, many showing bread-crusting, of total weight 73 lb. (33.11 kg.).

Remarks: The shale balls in the S.A.M. Collection were obtained by W. A. Cassidy and G. F. Gross in 1954. The sample of nickel-iron was presented by Dr. S. R. Taylor of the Australian National University in 1965.

NEW SOUTH WALES METEORITES

BARRATTA (Synonym—Baratta or Deniliquin) 35° 18′ S, 144° 34′ E

Stone, olivine-hypersthene chondrite.

Found 1845, 30 miles north-west of Deniliquin, N.S.W. Other finds were made in 1852 and 1899.

Total Weight: 202.7 kg. (447 lb.). Five masses. *Main masses* of 1st, 2nd, and 3rd stones in the Australian Museum, Sydney, N.S.W. 4th and 5th masses in the Field Museum of Natural History, Chicago, U.S.A.

S.A.M. Collection: G5676 (68 gm.). Slice.

CARTOONKANA 29° 20′ S, 141° 05′ E

Stone, enstatite chondrite.

Found prior to 1914, by T. F. Gill, on Yandama Station. Presented to the S.A. Museum by T. F. Gill in 1924.

Total Weight: About 12oz. (340 gm.). One mass.

S.A.M. Collection: *Main mass*
G5694 10¼oz. (290 gm.).

Remarks: Very like Yandama, but shows some differences.

Reference:
Alderman, A. R., 1936. Rec. S. Aust. Mus., 5, p. 537.

GILGOIN 30° 23′ S, 147° 12′ E

Stone, olivine-bronzite chondrite.

Found 1889, on Gilgoin Station, 40 miles east-south-east of Brewarrina, N.S.W. Another specimen was found in 1920 (No. 8.)

Total Weight: 144.7 kg. (319 lb.). Eight masses. *Main masses* of Nos. 1, 2, 6, 8 and part of 7 in the Australian Museum, Sydney. No. 5 in the Field Museum of Natural History, Chicago, U.S.A.

S.A.M. Collection: G4984A 4 lb. 13oz. (2.18 kg.).
G4984B 59 gm. Slice.
G4984C 2 lb. 12oz. (1.25 kg.) (Gilgoin No. 7).

MOLONG 33° 17′ S, 148° 53′ E

Stony-iron, pallasite.

Found 1912, 12 miles west of Orange, N.S.W.

Total Weight: 105.22 kg. (232 lb.). *Main mass* in Australian Museum, Sydney, N.S.W.

S.A.M. Collection: G6055A 6 lb. 5oz. (2.86 kg.).
G6055B 20 gm.

Remarks: Specimen in an exceedingly weathered and fragmentary condition.

MORDEN (Synonym—Mordan) 30° 30′ S, 142° 20′ E

Iron, hexahedrite.

Found 1922, in the Koonenberry Range, 5 miles from Morden Station, N.S.W., and 100 miles north-north-east of Broken Hill. Purchased by the S.A. Museum from the finder, J. W. Wickham, Cockatoo Valley, Gawler, S.A., in 1922.

Total Weight: 5¾ lb. (2.72 kg.).

S.A.M. Collection: *Main mass*
G5671A 4 lb. 12oz. (2.15 kg.).
G5671B 189 gm.
G5671C 42 gm.

Reference:
Alderman, A. R., 1936. Rec. S. Aust. Mus., 5, p. 537.

YANDAMA 29° 20′ S, 141° 05′ E

Stone, olivine-hypersthene chondrite.

Found prior to 1914, at Black's Camp, Big Plain, Yandama Station, north-west of N.S.W. Purchased by S.A. Museum from T. F. Gill in 1924.

Total Weight: Over 5.68 kg. (12 lb. 9oz.).

S.A.M. Collection: *Main mass*
G5693A 8 lb. (3.63 kg.).
G5693B 379 gm.

Reference:
Alderman, A. R., 1936. Rec. S. Aust. Mus., 5, p. 537.

VICTORIAN METEORITES

DIMBOOLA 36° 30′ S, 142° 02′ E

Stone, olivine-bronzite chondrite.

Found 1944, in a ploughed paddock near Dimboola, Victoria. Purchased by the South Australian Museum from C. F. Kurtze, Victoria, in 1944.

Total Weight: 36 lb. 8oz. (16.6 kg.). One mass. The original mass has been sliced into nine pieces.

S.A.M. Collection: *Main mass*
G5987A 15 lb. (6.80 kg.).
G5987B 13 lb. 4oz. (6.01 kg.).
G5987C 4 lb. 12oz. (2.15 kg.).
G5987D 308 gm.
G5987F 1 lb. 2½oz. (524.4 gm.).
G5987G 105 gm.

KULNINE 34° 06′ S, 141° 47′ E
Recalculated 34° 09′ S, 141° 47′ E

Stone, olivine-hypersthene chondrite.
Found about 1886, re-located 1911 by G. Crozier, on Kulnine Station, Victoria. Actual locality about 9 miles west of Wentworth and 3 miles from the Murray River. Purchased by the South Australian Museum from G. R. Annells in 1911.
Total Weight: 122 lb. (55.34 kg.). One mass.
S.A.M. Collection: *Main mass*
G5695A 65 lb. 4oz. (29.59 kg.).
G5695B 36 lb. 8oz. (16.56 kg.).
G5695C 3 lb. 4oz. (1.47 kg.).
G5695E 182 gm.
G5695F 40 gm.
G5695G 83 gm.
G5695H 278 gm.
Remarks: Previous catalogues have claimed Kulnine as a N.S.W. meteorite. A letter in the South Australian Archives from G. R. Annells to the South Australian Museum authorities, dated 21 July, 1911, states that the find was made in Victoria.

FOREIGN METEORITES

ADAMS COUNTY, Colorado, U.S.A. 39° 58′ N, 103° 46′ W
Stone, olivine-bronzite chondrite.
Found 1928.
S.A.M. Collection: G5687 106 gm.

AINSWORTH, Brown County, Nebraska, U.S.A. 42° 33′ N, 99° 48′ W
Iron, coarse octahedrite.
Found 1907.
S.A.M. Collection: G6123.

ARRIBA, Lincoln County, Colorado, U.S.A. 39° 18′ N, 103° 15′ W
Stone, olivine-hypersthene chondrite.
Found 1936.
S.A.M. Collection: G6120 250 gm.

BEARDSLEY, Rawlins County, Kansas, U.S.A. 39° 49′ N, 101° 14′ W
Stone, olivine-bronzite chondrite.
Fell 1929.
S.A.M. Collection: T1112 55 gm.

BEENHAM, Union County, New Mexico, U.S.A. 36° 13′ N, 103° 39′ W
Stone, olivine-hypersthene chondrite.
Found 1937.
S.A.M. Collection: T1116 134 gm. (2 pieces).

BLUFF, Fayette County, Texas, U.S.A. 29° 55′ N, 96° 50′ W
Stone, olivine-hypersthene chondrite.
Found about 1878.
S.A.M. Collection: G7101 750.2 gm.

BONITA SPRINGS, Lee County, Florida, U.S.A. 26° 16′ N, 81° 45′ W
Stone, olivine-bronzite chondrite.
S.A.M. Collection: G7961A 402 gm.
G7961B 261 gm.

BRENHAM, Kiowa County, Kansas, U.S.A. 37° 38′ N, 99° 05′ W
Stony-iron, pallasite.
Found 1882.
S.A.M. Collection: G5677 68 gm.
G7103 5,100 gm.
T1120 23 gm.

BREWSTER, Thomas County, Kansas, U.S.A. 39° 15′ N, 101° 20′ W
Stone, olivine-hypersthene chondrite.
Found 1940.
S.A.M. Collection: G6117 20 gm.

CAMPO DEL CIELO, Gran Chaco, Gualamba, Argentina 27° 28′ S, 60° 35′ W
Iron, hexahedrite.
Found 1576.
S.A.M. Collection: G7965 17 gm.

CANYON DIABLO, Coconino County, Arizona, U.S.A. 35° 03′ N, 111° 02′ W
Iron, coarse octahedrite.
Found 1891.
S.A.M. Collection: G4982 3,231.8 gm.
G7104 4,082.3 gm.
G4983 (iron shale) 443 gm.
G6086 (impactite) 7.5 gm.
G6087 metallic spheroids.
G6088 metallic spheroids.
G7964 139 gm.

CLOVER SPRINGS, Coconino County, Arizona, U.S.A. 34° 27′ N, 111° 22′ W
Iron, mesosiderite.
Found 1956.
S.A.M. Collection: G6119 44 gm.

DIMMITT, Castro County, Texas, U.S.A. 34° 35′ N, 102° 10′ W
Stone, olivine-bronzite chondrite.
Found before 1947.
S.A.M. Collection: G6118 10 gm.

DUCHESNE, Duchesne County, Utah, U.S.A. 40° 23′ N, 110° 52′ W
Iron, fine octahedrite.
Found 1906.
S.A.M. Collection: G5684 25 gm.

EL CAPITAN, Lincoln County, New Mexico, U.S.A. 33° 30′ N, 105° 30′ W
Iron, medium octahedrite.
Found 1893.
S.A.M. Collection: G7102 1,147 gm.

FOREST CITY, Winnebago County, Iowa, U.S.A. 43° 15′ N, 93° 40′ W
Stone, olivine-bronzite chondrite.
Fell 1890.
S.A.M. Collection: G5680 567 gm.

FORSYTH COUNTY, North Carolina, U.S.A. 36° 05′ N, 80° 15′ W
Iron, hexahedrite.
Found about 1891.
S.A.M. Collection: G6121 499 gm.

HOBA, Grootfontein, South-west Africa. 19° 35′ S, 17° 55′ E
Iron, nickel-rich ataxite.
Found 1920.
S.A.M. Collection: G7966A Iron shale 256 gm.
G7966B Iron shale 90 gm.
G7966C Iron shale 347 gm.

HOLBROOK, Navajo County, Arizona, U.S.A. 34° 54′ N, 110° 11′ W
Stone, olivine-hypersthene chondrite.
Fell 1912.
S.A.M. Collection: G5688 43 gm.

IDER, De Kalb County, Alabama, U.S.A. 34° 41′ N, 85° 39′ W
Iron, coarse octahedrite.
Found 1957.
S.A.M. Collection: G7963 201 gm.

JOHNSON CITY, Stanton County, Kansas, U.S.A. 37° 33′ N, 101° 41′ W
Stone, olivine-hypersthene chondrite.
Found 1937.
S.A.M. Collection: G6115 178.5 gm.

JOHNSTOWN, Weld County, Colorado, U.S.A. 40° 21′ N, 104° 54′ W
Stone, hypersthene achondrite.
Fell 1924.
S.A.M. Collection: G6126 494 gm.

KENDALL COUNTY, Texas, U.S.A. 29° 24′ N, 98° 30′ W
Iron, hexahedrite.
Known 1887.
S.A.M. Collection: G6124 625 gm.

KESEN, Iwate, Honshu, Japan. 38° 53′ N, 141° 35′ E
Stone, olivine-bronzite chondrite.
Fell 1850.
S.A.M. Collection: G7100 309 gm.

KINGFISHER, Kingfisher County, Oklahoma, U.S.A. 35° 50′ N, 97° 56′ W
Stone, olivine-hypersthene chondrite.
Found 1950.
S.A.M. Collection: G7348 87.5 gm.

MELROSE, Curry County, New Mexico, U.S.A. 34° 23′ N, 103° 37′ W
Stone, olivine-hypersthene chondrite.
Found before 1933.
S.A.M. Collection: T1122 38 gm.

MODOC, Scott County, Kansas, U.S.A. 38° 30′ N, 101° 06′ W
Stone, olivine-hypersthene chondrite.
Fell 1905.
S.A.M. Collection: G6125 453.6 gm.

MONAHANS, Ward County, Texas, U.S.A. 31° 50′ N, 102° 55′ W
Iron, nickel-rich ataxite.
Found 1938.
S.A.M. Collection: G6116 66 gm.

NESS COUNTY, Kansas, U.S.A. 38° 30′ N, 99° 36′ W
Stone, olivine-hypersthene chondrite.
Found 1894.
S.A.M. Collection: G6114 89 gm.

ODESSA, Ector County, Texas, U.S.A. 31° 43′ N, 102° 24′ W
Iron, coarse octahedrite.
Found before 1922.
S.A.M. Collection: G6052A 5.90 kg.
G6052B 7.26 kg.
G6052C 8.16 kg.
G6052D 2.27 kg.

PARAGOULD, Greene County, Arkansas, U.S.A. 36° 04′ N, 90° 30′ W
Stone, olivine-hypersthene chondrite.
Fell 1930.
S.A.M. Collection: G5993 190 gm.

PASAMONTE, Union County, New Mexico, U.S.A. 36° 13′ N, 103° 24′ W
Stone, pyroxene-plagioclase achondrite.
Fell 1933.
S.A.M. Collection: G5770 124 gm.
T1119 30 gm.

PLAINVIEW, Hale County, Texas, U.S.A. 34° 07′ N, 101° 47′ W
Stone, olivine-bronzite chondrite.
Found 1917.
S.A.M. Collection: T1113 765 gm.

PUENTE DEL ZACATE, Monclova district, Coahuila State, Mexico. 28° 42′ N, 102° 51′ W
Iron, medium octahedrite.
Found about 1904.
S.A.M. Collection: G5689 35 gm.

RICHARDSON, Stark County, North Dakota, U.S.A. 46° 53′ N, 102° 19′ W
Stone, olivine-bronzite chondrite.
Fell 1918.
S.A.M. Collection: G5689 160 gm.

ROY, Harding County, New Mexico, U.S.A. 35° 57′ N, 104° 12′ W
Stone, olivine-hypersthene chondrite.
Found 1933.
S.A.M. Collection: G5769 186 gm.

SANTA APOLONIA, Nativitas, Tlaxcala, Mexico. 19° 13′ N, 98° 18′ W
Iron, medium octahedrite.
Found 1872.
S.A.M. Collection: T1115 281 gm.
T1124 22 gm. (oxidized scale).

SARDIS, Burke County, Georgia, U.S.A. 32° 56′ N, 80° 51′ W
Iron, coarse octahedrite.
Found 1940.
S.A.M. Collection: G7962 1,570 gm.

SELMA, Dallas County, Alabama, U.S.A. 32° 24′ N, 87° 00′ W
Stone, olivine-bronzite chondrite.
Found 1906.
S.A.M. Collection: G6122 503 gm.

SPRINGWATER, Saskatchewan, Canada. 52° 00′ N, 108° 18′ W
Stony-iron, pallasite.
Found 1931.
S.A.M. Collection: G5686 198 gm.

TOLUCA, Mexico State, Mexico. 19° 34′ N, 99° 34′ W
Iron, medium octahedrite.
Known before 1776.
S.A.M. Collection: G5678 274 gm.
G5678A 794 gm.
T1121 21 gm.
T1128 13 gm. (oxidized scale).

WABAR, Rub'al Khali, Arabia. 21° 29′ N, 50° 28′ E
Iron, medium octahedrite.
Found 1932.
S.A.M. Collection: G6053A 13.5 gm. (iron).
G6053B 24.5 gm. (iron-shale).

WILLAMETTE, Clackamas County, Oregon, U.S.A. 45° 22′ N, 122° 35′ W
Iron, medium octahedrite.
Found 1902—associated with craters.
S.A.M. Collection: T1125 30 gm. (oxidized scale).

LIST OF METEORITES ACCORDING TO CLASS

Irons (*Siderites*):

Nickel-rich ataxites:
Alikatnima, Hoba, Monahans, Tawallah Valley.

Coarse octahedrites:
Ainsworth, Canyon Diablo, Ider, Odessa, Sardis.

Medium octahedrites:
Boxhole, Cowell, El Capitan, Haig, Henbury, Kyancutta, Moorumbunna, Puente del Zacate, Rhine Villa, Santa Apollonia, Toluca, Warbar, Willamette, Wolf Creek, Yardea.

Fine octahedrites:
Duchesne, Mt. Sir Charles.

Hexahedrites:
Campo del Cielo, Forsyth Co., Kendall Co., Morden.

Metabolites:
Arltunga, Murnpeowie.

Stony-irons (*Siderolites*):

Pallasites:
Brenham, Huckitta, Molong, Springwater.

Mesosiderites:
Clover Springs, Dalgaranga, Pinnaroo.

Stones (*Aerolites*):

Enstatite chondrites:
Cartoonkana.

Olivine-bronzite chondrites:
Adams Co., Beardsley, Bonita Springs, Caroline, Cocklebiddy, Coomandook, Coonana, Dimboola, Dimmitt, Forest City, Gilgoin, Kaldoonera Hill, Kesen, Plainview, Richardton, Selma.

Olivine-hypersthene chondrites:
Accalana, Arriba, Artracoona, Barratta, Beenham, Bluff, Brewster, Cadell, Carraweena, Cocunda, Holbrook, Johnson City, Kingfisher, Kingoonya, Kulnine, Lake Bonney, Lake Brown, Lake Grace, Lake Labyrinth, Melrose, Modoc, Monte Colina, Ness Co., Nora Creina, Paragould, Roy, Vincent, Wingellina, Yandama.

Olivine-pigeonite chondrites:
Karoonda.

Chondrites—unclassified:
Crockers Well, Wilbia.

Hypersthene achondrites:
Johnstown.

Pyroxene-plagioclase achondrites:
Pasamonte.

MISCELLANEA

Several undocumented meteorites were included in the S. F. C. Cook Collection of minerals and tektites purchased by the S.A. Museum in 1945. With one exception, it has not been possible to establish the relationship of these meteorites to previously described specimens, but it is probable that all are of Australian origin. The undocumented specimens are as follows:—

G6062	347 gm.	Stone.
G6063, G6064, G6076	281.5 gm.	Stone, olivine-bronzite chondrite. Three pieces.
G6067	38 gm.	Iron.
G6069-6072	261.5 gm.	Iron. Four pieces.

Other meteorites of unknown origin in the Museum Collection are:—

G6075	171 gm.	Stony-iron (acquired from H. A. Lindsay).
G6092	9 gm.	Iron, New Mexico.
G5679	146 gm.	Iron, Mexico.

Casts of the following meteorites are also included in the collection:—

Adelie Land (Antarctica)
Arltunga (N.T.)
Artracoona (S.A.)
Bingera (N.S.W.)
Boogaldi (N.S.W.)
Bustee (India)
Carraweena (S.A.)
Cartoonkana (N.S.W.)
Coomandook (S.A.)
Cowell (S.A.)
Eli Elwah (N.S.W.)
Kulnine (Vic.)
Mangwendi (Southern Rhodesia)
Moorumbunna (S.A.)
Morden (N.S.W.)
Nocoleche (N.S.W.)
Rhine Villa (S.A.)
Roeburn (W.A.)
Rowton (England)
Tenham (Q.)
Wilbia (S.A.)
Wold Cottage (England)
Yandama (N.S.W.)
Yardea (S.A.)

GENERAL REFERENCES

Hey, M. H., 1966: Catalogue of Meteorites, 3rd Edition, London, British Museum (Natural History).

Hodge-Smith, T., 1939: Australian Meteorites. Mem. Aust. Mus., No. 7, pp. 1-84.

McCall, G. J. H., and DeLaeter, J. R., 1965. Catalogue of Western Australian Meteorite Collections. Spec. Publ. W. Aust. Mus. No. 3.

ACKNOWLEDGMENTS

The undescribed meteorites in the collection were loaned to Dr. J. F. Lovering of the Australian National University, Canberra, for a number of years, and descriptions of these will be published in due course. The author wishes to thank Dr. Lovering for information pertaining to those meteorites which are included in this catalogue.

Thanks are also due to Dr. B. Mason, Curator, Division of Meteorites, U.S. National Museum, Washington, for permission to include unpublished data on several South Australian meteorites.

The assistance of the Director of Lands in checking certain inconsistencies in the locations of a number of South Australian meteorites is here acknowledged.

Finally, the author offers his grateful thanks to Miss J. Scrymgour for her invaluable assistance during all stages in the preparation of the catalogue.

SHORT NOTES

FURTHER ADDITIONS TO THE FISH FAUNA OF SOUTH AUSTRALIA

By C. J. M. GLOVER, South Australian Museum

The following ten marine species are added to the fish fauna of South Australia as listed by Scott (1962) and Glover (1966).

All have previously been recorded elsewhere in Australia.

Each specimen referred to constitutes a first record for the State and is preserved in the South Australian Museum. Of the three species illustrated herein *Petraites johnstoni* has not been figured previously in the Australian literature.

Family SQUALIDAE

Squalus megalops (Macleay)

Acanthias megalops Macleay, Proc. Linn. Soc. N.S. Wales, vi, 2, Sept. 12, 1881, p. 367.

A female specimen was taken by hand line off Normanville on March 20, 1966; L.C.F., 44.5 cm.; S.A.M. Reg. No. F3430.

Family SYNGNATHIDAE

Yozia trigris (Castelnau)

Syngnathus tigris Castelnau, Proc. Linn. Soc. N.S. Wales, iii, 4, May 1879, p. 397.

A single specimen, lacking a brood pouch, was collected near the Port Pirie jetty by Mr. W. T. Wehrman on October 1, 1967; T.L., 25.8 cm.; S.A.M. Reg. No. F3438.

Maroubra perserrata Whitley

Maroubra perserrata Whitley, Rec. Austr. Mus. 22 (1): 74-95, 1948.

Two specimens, lacking brood pouches, were collected at Port Noarlunga reef by Mr. B. G. Brawley on September 7, 1967, at a depth of approximately 9.0 m.; T.L.'s 5.9 cm. and 6.8 cm. respectively; S.A.M. Reg. No. F3439.

Ichthyocampus runa (Whitley)

Festucalex (*Campichthys*) *runa* Whitley, Austr. Zool., 6; 1931: p. 313.

A specimen, lacking a brood pouch, was collected in shallow water at Aldinga reef by Mr. B. Saunders on December 8, 1965; T.L., 6.8 cm.; S.A.M. Reg. No. F3440.

Lissocampus affinis Whitley

Lissocampus affinis Whitley, Austr. Zool. 10, 1944, p. 266.

A male specimen, with brood pouch developed, was collected by the author at Sceale Bay on October 7, 1964; T.L., 8.2 cm.; S.A.M. Reg. No. F3245.

Nannocampus ruber Ramsay and Ogilby

Nannocampus ruber Ramsay and Ogilby, Proc. Linn. Soc. N.S. Wales, x, 4, Apr. 3, 1886, p. 757.

A specimen, lacking a brood pouch, was taken from a craypot at Cape Jaffa by Mr. I. R. McInnes on February 19, 1964; T.L., 13.7 cm.; S.A.M. Reg. No. F3220.

Urocampus carinirostris Castelnau

Urocampus carinirostris Castelnau, Proc. Zool. Acclim. Soc. Vict., 1, July 15, 1872, p. 200.

A specimen was collected in shallow water at Davenport Creek, near Ceduna, by Mr. B. Taylor on September 30, 1965; T.L. 6.5 cm.; S.A.M. Reg. No. F3441.

Family TERAPONTIDAE

Therapon humeralis Ogilby

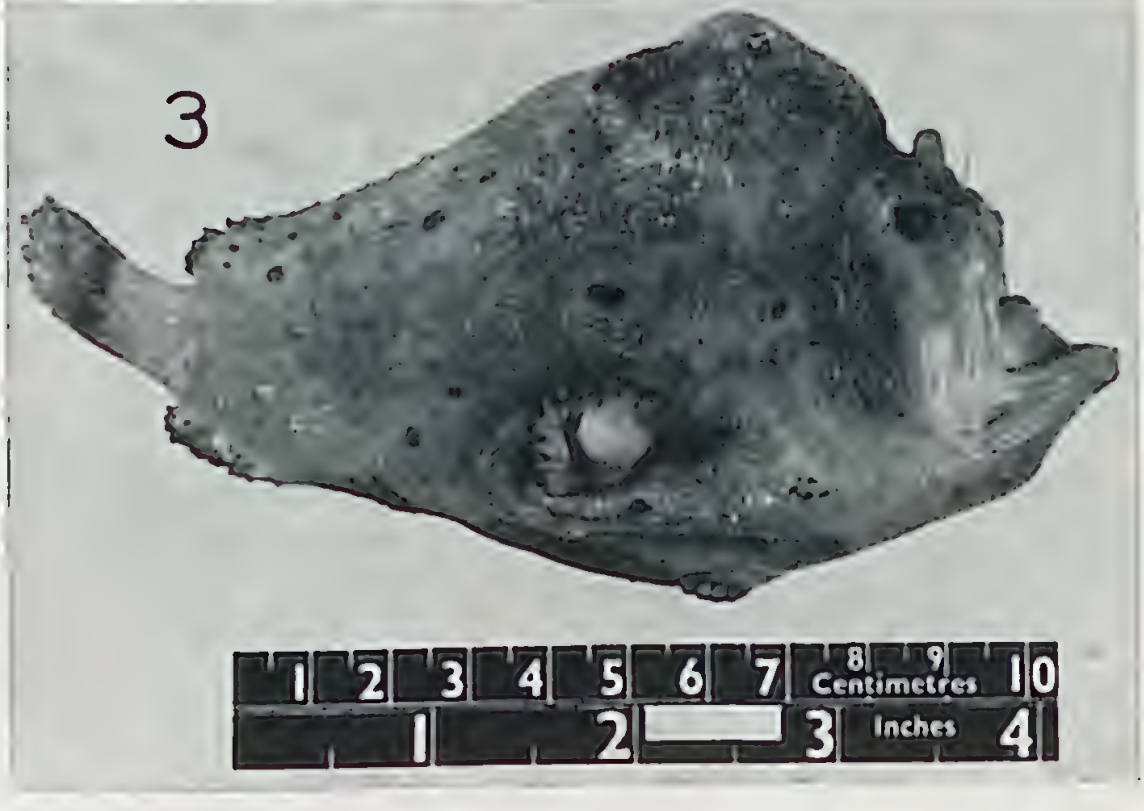
Therapon humeralis Ogilby, Proc. Linn. Soc. N.S. Wales, xxiv, 1, Aug. 8, 1899, p. 177.

Two specimens were taken by line in the surf zone at Streaky Bay by Mr. J. Lampard in January, 1968; S.L.'s 23.0 cm. and 27.0 cm. respectively; S.A.M. Reg. Nos. F3442 and F3443 (Fig. 1).

Fig. 1. *Therapon humeralis* Ogilby; S.A.M. Reg. No. F3443.
Fig. 2. *Petraites johnstoni* (Saville-Kent); S.A.M. Reg. No. F3444.
Fig. 3. *Echinophryne glauerti* Whitley; S.A.M. Reg. No. F3429.

1

2
Centimetres
Inches


3
1 2 3 4 5 6 7 8 9 10
Centimetres
1 2 3 4
Inches

Family CLINIDAE

Petraites johnstoni (Saville-Kent)

Clinus johnstoni Saville-Kent, Rept. Fish. Dept. Tasm., 1886, p. 13.

A specimen (Fig. 2) was speared at Carpenters Rocks, in the South-East, by Mr. K. J. Pulford in May 1967; S.L. 29.0 cm.; S.A.M. Reg. No. F3444.

Family ANTENNARIIDAE

Echinophryne glauerti Whitley

Echinophryne glauerti Whitley, Austr. Zool. 10, pt. 3, 1944, p. 272.

A specimen (Fig. 3) was taken by Mr. M. Leech from a craypot that had been set at a depth of approximately 62 m. off Pearson Island (S.W. of Elliston) on January 15, 1967; S.L. 11.5 cm.; S.A.M. Reg. No. F3429.

ACKNOWLEDGMENTS

The author is grateful to Mr. R. J. McKay (The Western Australian Museum), Dr. J. R. Paxton (The Australian Museum) and Mr. A. P. Andrews (The Tasmanian Museum) for making available comparative material and comparing certain specimens.

Appreciation is also expressed to officers of the South Australian Fisheries and Fauna Conservation Department and others who have co-operated in forwarding specimens to the Museum.

REFERENCES

Glover, C. J. M., 1966: Three Fishes Previously Unrecorded from South Australia. Rec. S. Austr. Mus., 15 (2).

McCulloch, A. R., 1929-30: A Check-List of the Fishes Recorded from Australia. Austr. Mus. Mem., 5 (1-4): i-x and 1-534.

Scott, T. D., 1962: The Marine and Fresh Water Fishes of South Australia. Adelaide: Govt. Printer.

Whitley, G. P., 1948: A List of the Fishes of Western Australia. W.A. Fisheries Dept. Bull., 2: 1-35 and map.

Whitley, G. P., 1964: A Survey of Australian Ichthyology. Proc. Linn. Soc. N.S. Wales, lxxxix, 1, pp. 11-127.

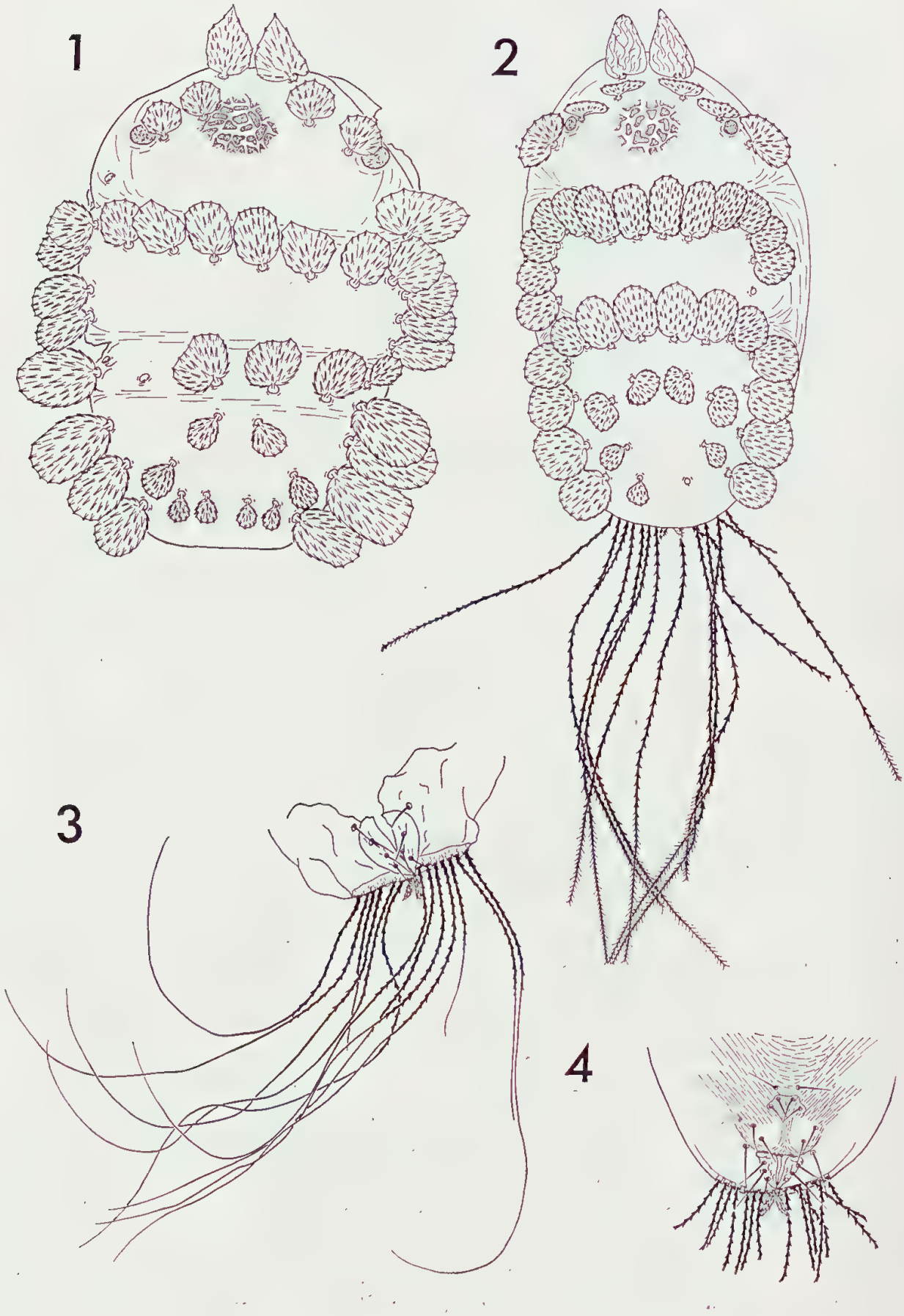
REDESCRIPTION OF TUCKERELLA SPECHTAE WOMERSLEY

By CLIVE D. JORGENSEN, Brigham Young University, Provo, Utah

Womersley (1957) described a new species of *Tuckerella* from South Australia, for which only one specimen was available. The number of caudal flagellate setae (seven) and the relative sizes of the dorsal hysterosomal setae formed the basis of the new species. Miller (1964) examined the type specimen and found it to be male rather than female as described by Womersley (1957). A species (*coleogynis*) endemic to North America was described by Jorgensen (1967) and it too had seven caudal flagellate setae and the dorsal hysterosomal setae were similar to those described for *spechtae*.

An examination of the type specimen revealed some errors made in the original description and some of the most diagnostic characters had not been adequately considered. Also the specimen was rather badly mashed and broken in the process of mounting, and the cover glass had been cracked, thus, remounting is not possible. Because of the inadequate description and the possibility of the specimen drying out and becoming useless, a re-description seemed necessary. It also seemed advisable to describe the female even though it is without adequate collection data. I am grateful to Mr. D. C. Lee, South Australian Museum, for the loan of the type specimen and the female of *spechtae*.

Male (Figs. 1 and 3)—The type specimen is male rather than female. Measurements are not especially useful because of the mashed condition of the specimen. Colour in life red. Body semi-oval; divided with sutures between propodosoma, metapodosoma, and opisthosoma; weak suture immediately posterior of the anterior transverse row of dorsal palmate opisthosomal setae; integument reticulate. One pair of eyes; if second pair is present it is obscured in the mounting. Four pairs of palmate propodosomal setae, the fourth (postero-lateral) being largest and flared out posteriorly. Four pairs of palmate dorsal metapodosomal setae, and three pairs of laterals; all are subequal in size. Seven pairs of palmate dorsal opisthosomal setae; three pairs on anterior margin (the lateral pair being much smaller than the two interior pairs); and four pairs arranged posteriorly. Posterior four dorsal opisthosomal setae arranged in transverse row and smaller than all other dorsal setae. Four pairs of lateral opisthosomal setae, with posterior pair being slightly smaller than the other three. Seven pairs of flagellate caudal setae, ciliated on proximal end only; one pair of small medio-caudal, foliaceous setae; all caudal setae arising from distinct tubercles; third caudal setae from the outside less than one-half the length of all others. Palpus with a well developed thumb and


1
2
3
4

claw; thumb with five setae about equal length. Legs short and stout with pulvillus and two well developed claws; tenant hairs originating from lateral margin of claws and pulvillus; tarsus I-IV each with one sensory rod, rod on tarsus I slightly narrower and longer than others. Setae on dorsal surface of legs palmate, with four simple setae on tarsus I and II. Four pairs of simple setae in genito-anal region; although the fifth (most anterior) is probably present and simply lost in the mounting.

Female (Figs. 2 and 4)—Body semi-oval, divided with suture, between propodosoma, metapodosoma, and opisthosoma; integument reticulate. One pair of eyes. Number of dorsal palmate setae same as male; posterior two pairs of dorsal opisthosomal setae not in transverse row as in male, second and third dorsal palmate setae on propodosoma flattened and flared out rather than rounded as in the male. Caudal flagellate setae weakly plumose on distal end; one pair of small medio-caudal foliaceous setae; third caudal setae from outside short and not plumose on distal end. Palpus similar to male. Legs similar to male except tarsus I has two sensory rods, the distal almost twice as long as the proximal; tarsus II-IV each with one sensory rod subequal in length to the proximal on tarsus I. Two long and three short simple setae on tarsus I. Nine pairs of simple setae in genito-anal region.

The type data are precisely the same as reported by Womersley (1957), except the holotype is male rather than female. The female has no data, but was considered to be *spechtae* because of the length of the third flagellate caudal setae. This character separates *spechtae* from all other species of *Tuckerella*. The holotype (N196839) and the single female specimen (N196840) are at the South Australian Museum.

REFERENCES

Jorgensen, C. D., 1967: A new species of *Tuckerella* (Acarina: Tuckerellidae) from Nevada. Entomol. News, 78: 141-146.

Miller, L. W., 1964: A new species of *Tuckerella* (Acarina, Tetranychoidea, Tuckerellidae) from Tasmania. Papers and Proc. Roy. Soc. Tasmania, 98: 79-84.

Womersley, H., 1957: A new species of *Tuckerella* (Acarina, Tetranychoidea, Tuckerellidae) from South Australia. Trans. Roy. Soc. S. Australia, 80: 73-75.

Figs. 1-4. *Tuckerella spechtae* Womersley. 1 and 3, male: 1, dorsal surface of idiosoma; 3, genito-anal region. 2 and 4, female: 2, dorsal surface of idiosoma; 4, genito-anal region.

PAGE

aberrans, Ctenoneurus . . . 513, 531, 532, 536, 550
aberrans, Ologamasus . . 205, 208, 209, 226
absimilis, Holochila . . 166, 168, 170, 171
abundans, Retrodrymus 45, 63, 78
Acacia 135, 175, 310
Acaraptera 302, 303
acuminata, *see* aspersa acuminata, Helix
acuminatus, Psilaster 755
acuta, Cochlicella 79, 82, 83, 85-87, 484-486
acutus, Calisius 282, 291
adelaidae, Ceratosoma 333
adelaidensis, Amphibolurus . 180, 183, 184, 185, 186, 187, 188
Aegisocoris 513, 521, 525
aenea, Sphalangia 552
aeneus, Trimorus 552
affinis, Aphelodoris 337
affinis, Calisius 282
affinis, Hyla 712, 719, 721
affinis, Lissocampus 792
affinis, Pelodytes 719, 722
Agonophorus 551, 553
Agunga 64
aitkeni, *see* cavernarum aitkeni, Protochelifer
alba, Tyto 578
albicornis, Aradus . . 277, 278, 279, 284
albicornis, Mezira 278
albifrons, Phylidonyris 699
albina, *see* donnysa albina, Hesperilla
albovenata, Anisynta 175, 177
albovenata weemala, Anisynta 177
aleurodinis, Amitus 552
aleurodis, Elaptus & Alaptus 552
alliarius, Oxychilus . . . 257-260, 484-486
Allostichaster 752
Amphibolurus 179, 185, 188, 190
Amyema 699
Anadara 599
anaemus, Calisius 282
androphymus, Aneurus 293
Aneurus 293
angasi, Bullaea 331
angasi, Philine 331, 332
angiana, Hyla 357
Angophora 702
angulatus, Aneurus 293
angulatus, Mastigocoris 514
angustidens, Phascolomys 405
annulicornis, Calisius 283, 284, 287
antarctica, Nothofagus 501
antennalis, Calisius 282
antennatus, Aradus 279
Anthaster 743
antillensis, Aphelodoris 336, 337
antipodum, Ideobisium 757, 760, 762
antipodum, Obisium 762
apetala, Pomaderris 165

PAGE

Aphelodoris 329, 336, 337
Appolonius 40, 42, 61, 64, 74
Aradacanthia 280, 281
Aradus 276, 277, 279
araklai, Calisius 282
arcystatus, Echinaster . . 750, 751, 754, 755
Argocoris 513, 519
Arictus 541
Artabanellus 517
Artabanus 526
aspersa, Helix . . 79, 81, 85, 86, 87, 483, 484, 485, 486, 493, 494
aspersa acuminata, Helix 81
Aspisocoris 513, 515, 517
Asterina 745
Asterodiscus 737
astrologorum, Tosia 741, 742
Astropecten 730, 732, 735, 736
atkinsoni, Artabanus 527
atyphoida, Asterina . . 731, 745, 754, 755
aurea, Doriopsilla 347, 350, 351
aurea, Doris 350
auritomentosa, Daulocoris . . 513, 546, 547
australiae, Luidia 730, 732, 755
australiae, Maculaster 732
australasiae, Paranura 274
australica, Lobella 261, 264, 265, 274
australicus, Aneurus 294
australiensis, Mediaster 755
australis, Aradus 277, 279, 280, 284
australis, Austrochthonius 758
australis, Brachyrhynchus 542
australis, Calisius 283, 284, 287
australis, Carventus 300
australis, Crimia 542
australis, Ctenoneurus 532
australis, Isopeltus . . . 45, 51, 54, 55, 78
australis, Mezira 542, 543
australis, Odinia 755
australis, Taphropeltus 39, 40, 50, 51
australis, Tosia 741, 742, 754
Austrodrymus 42, 71, 74
Austrofromia 744

balticus, Calisius 281
Banksia 71, 72, 699, 702
barbatus, Amphibolurus 181, 183
Barcinus 526, 533
barnardi, Lasiorhinus . . 394, 395, 396, 397
barnardi, *see* latifrons barnardi, Lasiorhinus
basilewskyi, Chelonoderus 519
baxteri, Eucalyptus 576
becki, Hyla 359
berghi, Aphelodoris 329, 337, 343, 345, 348
bergrothianus, Ctenoneurus 530
beta, Arictus 541
beta, Mezira 541
bibroni, Pseudophryne 707, 709
bilobatus, Calisius 282

PAGE

Bilobella 261
bilobiceps, Artabanus 527
bilobiceps, Brachyrrhynchus 527
bilobiceps papuasicus, Artabanus . 513, 527, 550
Biroana 303
biroi, Carventus 300
bizona, *see* ventrosa bizona, Cochlicella
boaris, Maytenus 501
booroolongensis, Hyla 711, 719
bornemisszai, Pseudotyrannochthonius 760
Brachydrymus 41, 72, 74
Brachyodontes 628
brachypterus, Carventus . . 299, 301, 302, 549
Brentiscerus 40, 42, 54, 55, 61, 74
brevicaudatum, Ceratosoma 333
brevirostris, Melithreptus 702
brevispina, Patiriella 745, 747, 755
brunnea, Aphelodoris 337
Burgeonia 295

caerulea, Hyla 360
calamaria, Coscinasterias . . 731, 751, 755
calcar, Asterias 746
calcar, Patiriella 745, 746, 747, 755
calcarellus, Heterogamasus (Heterogamasus) . . 497, 498, 500, 503, 504, 505
Calisiopsis 281
Calisius 275, 281, 286
Callistemon 599
camaldulensis, Eucalyptus 69, 587
Camerarius 295
Candalides 166
caperata, Helicella 80, 484, 485, 486
carinirostris, Urocampus 792
carneola, Doriopsilla 347, 350
carneola, Doris 350
carronii, Bauhinia 673
carunculata, Anthochaera 702
Carventus 275, 295, 300, 301, 302
carvi, Neodoris 336
Cassidula 496
Castoroides 456
Casuarina 71
cavei, Ologamasus 206
cavernarum, Protochelifer 764, 765
cavernarum aitkeni, Protochelifer . 757, 760, 764
cavicola, Austrochthonius 757, 760
cecidomyiarum, Diapria 554
cellarius, Oxychilus 260
Cepea 85
cephalus gigas, Tympanocryptis . . 181, 183, 184, 187, 188
Ceraphron 551, 557
cetratus, Aneurus 294
Chelonoderus 519, 525
Chlamydosaurus 181, 183
Chloritobadistes 84
chrysoderma, Neodoris 336
chrysops, Meliphaga 699
chrysoptera, Anthochaera 702

PAGE

ciliatus, Psilus 554
cincticornis, Appolonius 65
cincticornis, Ophthalmicus 65
c.f. cirrata, Neanura 261, 266, 267, 270, 273
cirratus Achorutes 266
cirratus, *see* hirtellus cirratus, Achorutes
citiatus, Polynema 554
cladocalyx, Eucalyptus 700, 702
claviger, Heterogamasus 497, 501
claviger, Heterogamasus (Heterogamasus) 497, 498, 500, 501, 502
cneorifolia, Eucalyptus 310
cognatus, Calisius 282, 293
cognatus, Scolopostethus 68
coleogynis, Tuckerella 795
coleoptratus, Ologamasus 206
completa, Acaraptera 307
confusus, Calisius 282
conica, Chalcis 552
conica, Diapria 552
conicus, ?Cynipsichneumon 552
conicus, Ichneumon 552
consimilis, Holochila 166, 168, 169
conspurcata, Helicella 84
constrictus, Prosympiestus 276
contraria *see* thersites contrario, Zoila
contubernalis, Calisius 282
coplandi, Hyla 714, 715, 716, 717, 718, 719, 720, 724, 725
Correa 310
Coscinasterias 751
cosmophylla, Eucalyptus 310, 576
crassimanus, Pentagonaster 739
crassipes, Cynips 552
crassus, Appolonius 65
cratitia, Meliphaga 699, 702
crenulatus, Aneurus 294
Crimia 533
Crinia 705
cristatus, Amphibolurus . . 180, 184, 187, 188, 189
crowcrofti, Rhizophascolonus . . 454, 455
Ctenoneurus 514, 530, 532
cunninghamii, Muehlenbeckia 673
cunninghamii, Nothofagus 225
Cupania 171
cymosus, Ologamasus . . 205, 206, 209, 210, 211, 212, 213, 214, 216, 218, 220, 222, 226
cynipseus, Litus 552
Cyrtolaelaps 205, 206, 208, 501
Cystophora 744

darlingtoni, Amphibolurus . . . 180, 184, 185, 187
darwini, Berberis 501
decanus, Echinaster 751, 755
decanus, Plectaster 731, 751
decresii, Amphibolurus . . 180, 183, 184, 187
denticeps, Acaraptera . . 299, 306, 307, 549

PAGE

destructor, Ceraphron 553
destructor, Merisus 553
Diapria 554
diemensis, Amphibolurus .. 180, 181, 183, 184, 185, 187
diffusus, Brentiscerus 56, 60, 78
dilaticeps, Calisius 282
dimidiatus, Mizaldus 43
dimidiatus, Rhyparochromus 43
dimorpha, Acaraptera 299, 303, 305, 549
dimorpha *see* helenita dimorpha, Holochila
diosmifolium, Helichrysum 52
Diplodactylus 189
Diprotodon 419, 420, 422
discutatus, Ologamasus .. 205, 206, 207, 209, 210, 211, 212, 225, 226, 227, 228, 230, 231, 233
diversifolia, Eucalyptus .. 310, 700, 701, 702
dolobrata, Pinna 751
donnysa albina, Hesperilla 176
doreica, Crimia 526, 530
doreicus, Artabanus 530
dorsalis, Limnodynastes 360
Drakiessa 523, 526
Drymus 71, 74
dübeni, Pentagonaster 739
dubius, Australiaster 754, 755
duebeni, Pentagonaster .. 730, 739, 740, 742, 743, 744, 755
dumosa, Eucalyptus 676
dumosus, Ologamasus .. 205, 210, 218, 219, 220, 222
dyscrita, Cosmasterias 755

Echinaster 731, 750
Ecklonia 742, 744
Ektopodon 438, 442, 443, 444, 445
elegans, Eurynome 29, 35, 36, 37
elegans, Mezira 513, 543, 546, 550
elegantulus, Calisius 282
elongatus, Pictinellus .. 513, 534, 539, 540, 544, 550
enigmatica, Gastrodomorpha .. 61, 62, 78
enigmatica, Mezira .. 513, 544, 547, 550
enodis, Chorizandra 312
erinacea, Neodoris 336
erraticus, Aradus .. 277, 280, 284, 549
essingtonensis, Cyrena 158
Eucalyptus .. 233, 287, 427, 428, 429, 432, 433, 436, 458, 605, 699
Eucrassatella 625
Euepicrius 206, 208
Eulophus 554
Eupelmus 554
Eurynome .. .. *29* et seq
Euryparasitus 205, 208
Evanssellus .. 206, 497, 498, 499, 500, 505
exigua, Asterias 746
exigua, Patiriella 745, 746, 754, 755
exilirostris, Paradrymus .. 39, 45, 49, 78

PAGE

farri, Calisius 282
feanus, Daulocoris 513, 546
ferox, Calisius 282
Ferussacia 80, 483-486
fionii, Amphibolurus 180, 184, 187
flindersensis, Zosterops 577, 578
flindersi, Austrodrymus 45, 72, 78
florestalis, Pseudodrymus 45, 70, 78
floridanus, Chirocerus 552
floridanus, Lygocerus 552
foliatus, Evanssellus 497, 498, 510
foliatus, Heterogamasus (Evanssellus) 347, 498, 500, 505, 509, 510
folliculus, Ferussacia 80
forcififer, Lonchotaster 755
forticornis, Scolopostethus 45, 68, 78
freycinetti, Hyla 711
friendi friendi, Zoila 252
friendi vercoi, Zoila 252
fulvipes, Eupteromalus 554
fungicola, Ctenoneurus 534
fungicola, Pictinellus .. 534, 535, 536, 539
fuscata, Anisynta albovenata 176, 177
fuscicornis, Aradus 277, 278, 284, 549

Galesus 554
Gamaselliphis 206, 209
Gamasellus .. 205, 209, 226, 497, 498, 505
Gamasiphis 206, 208, 510
Gamasiphoides 208
Gastrodes 55, 61
Gastrodomorpha 42, 61, 74
Gelidium 746
geniculatus, Artabanus 527, 528
gerriphagus, Tiphodytes 552
gestroi, Carventus 296
ghiliani, Calisius 281
gigas, *see* cephalus gigas, Tympanocryptis
gigas, Phascolonus 420, 422, 424
gilberti, Holochila 173
gillespiei, Lasiorhinus .. 383, 392, 393, 395, 396, 397
glabra, Morgania 673
glauerti, Echinophryne 792, 794
Glochocoris 513, 534, 541
glomeratus, Echinaster .. 750, 751, 754, 755
glycinoides, Clematis 169
goliath, Procoptodon 420
goodingi, Holochila .. 165, 166, 167, 168, 169, 174
gouldi, *see* lateralis gouldi, Zosterops
gracilis, Calisius 282
gracilis, Lamellaxis 79
gracilis, Radiaster 755
grandidieri, Philaemon 356
grandis, Nepanthia 748
grandis, Paranepanthia .. 731, 747, 748, 755
granifera, Asterias 753
granifera, Uniophora 753, 754, 755
granulatus, Aegisocoris 513, 514, 522, 523, 536, 550
granulosa, Eurynome .. .. *29* et seq

PAGE

greeni, Aphelodoris 329, 337, 342, 343, 345
griffithsioides, Neomonospora 477
grossi, Argocoris . . . 513, 514, 520, 521, 536, 550
grossi, Calisius 283, 284, 287, 549
grossi, Neanura 261, 272, 273
Gryon 553
gularis, *see* maculatus gularis, Amphibolurus
gularis, Melithreptus 699
gunni, Patiriella 745, 747, 755
gunni, Pentagonaster 739
gunnii, Asterina 747

hackeri, Calisius . . . 283, 284, 287, 288
hackeri, Chelonoderus 519, 523
hackeri, Drakiessa 519, 523
Hadra 84
hadracantha, Nepanthia 748, 749
haematodus moluccanus, Trichoglossus 701
halaszfyi, Ctenoneurus 530
halmaturina, *see* lateralis halmaturina, Zosterops
Haloa 331
Halophila 742, 751, 754
halyaetus, Hypochrysops 176
hamiltonsmithi, Pseudotyrannochthonius 757, 759, 760
Haminoea 331
hanschini, Neuroctenus 532
hartmeyeri, Astropecten 735
helenita, Holochila 172, 173
helenita dimorpha, Holochila 172
Helicella 82, 85, 487
Helix 85
hemiglauca, Atalaya 673
Heterogamasus . . 206, 497, 498, 500, 510
Heterogamasus (Heterogamasus) . 497, 499, 500, 505
hirsutus, Vombatus 399, 401-417
hirsutum, Opossum 398
hirtellus cirratus, Achorutes . . . 266-267
hirtellus schoetti, Achorutes 273, 274
hirtellus wellingtonia, Achorutes . . . 268
Holochila 165, 166
horvathi, Calisius 282
humeralis, Therapon 692
hyadesi, Henricia 755
Hydrogamasus 206
Hyla 711, 712, 720

idmo idmo, Agyris 176
inermis, *see* reticulatus inermis, Amphibolurus
infantulus, Glochocoris 513, 534
infantulus, Mezira (Mezirella) . . 513, 533, 534
infantulus, Pictinellus 513, 533
inflata, *see* ventrosa inflata, Cochlicella
infuscatus, Calisius 282
ingulba, Nicotiana 651

PAGE

inopina, Asterina 754
insignis, Calisius 282
insulare, Myoporum 310
intervenius, Calisius . . 280, 283, 284, 287
intima, Tympanocryptis . . 181, 184, 185, 186, 187, 188
irregularis, Pyrura 753
irregularis, Smilasterias . . . 731, 754, 755
Ismarus 551, 553
Isodermus 275
Isopeltus 42, 49, 55, 61, 74
izzardi, Arictus 541
izzardi, Mezira 541

johnsonii, Crocodilus 377
johnstoni, Clinus 794
johnstoni, Petraites 791, 792, 794
juliae, Aphelodoris 329, 337, 341, 342, 343

kirkaldyi, Carventus 301
kreftii, Phascolomys 409
kutjamarpensis, Litokoala 446, 447

laevis, Crinia 705, 707
Lamprohaminoea 331
lanceolatus, Masturus 353, 354, 355
landsdowneana, Eucalyptus 702
Lasiorhinus 390, 405, 456
lasiorhinus, Phascolomys 390
lateabundans, Brachydrymus . . 45, 73, 78
lateralis, Zosterops 577
lateralis gouldi, Zosterops 577
lateralis halmaturina, Zosterops . . . 577
latifrons, Lasiorhinus . . . 383 *et seq*, 399, 401-417, 425
latifrons barnardi, Lasiorhinus . . 383, 392
latifrons, Phascolomys 390, 407, 409
lativentris, Artabanus 527
lativentris, Calisius 282
latopalmata, Hyla . . 711, 718, 719, 720, 721, 723, 724, 726
latopalmata latopalmata, Hyla 719
latopalmata watjulumensis, Hyla 712, 713, 716, 718, 726
latopalmata, Litoria 719
Laurencia 746, 747
lawsae, Aphelodoris . . 329, 334, 337, 338, 341, 342, 348
leai, Calisius 283, 284, 290, 291, 549
leai, Pictinellus 513, 534, 536, 550
lecanii, Platygaster 554
lepidus, Cercartetus 575, 576
leptophylla, Eucalyptus 702
leptosceles, Ologamasus . . 205, 210, 216, 217
lesueuri, Hyla 711, 712, 713, 719, 724, 725
leucotelus, Aradus 277, 279, 284
leucotelus, Mezira 279
leucotis, Meliphaga 702
lineata lineata, Tympanocryptis . . 181, 183, 184, 185, 186, 187, 188
Lissaptera 302

PAGE

Litokoala 446, 448-454
litoprothrix, Ologamasus . . 205, 210, 225, 227, 229
littoralis, Parasitiphis 206
Lobella 262
lobuliventris, Arictus 541
lobuliventris, Mezira 541
longiceps, Pictinellus . . 513, 534, 539, 540, 544, 550
longicornis, Calisius 282
longifolia, Eucalyptus 429
longiventris, Calisius 282
luctuosa, Aphelodoris 337, 343
luctuosa, Doris 343
lugubris, Aradus 277, 279
Luidia 732
lunatus, Melithreptus 699
lycimnia, Coccophagus 554
Lygocerus 553

macracantha, Zoroaster 755
macrobrachia, Nectria . . . 467, 468, 474, 476-481, 738, 755
macropunctatus, Callistemon . . . 310, 700, 701, 702
Macrostigma 553
Maculaster 732
maculatus gularis, Amphibolurus . 180, 181, 184, 185, 186, 187, 189
maculosa, Amphibolurus 179, 190
maculosa, Tympanocryptis . . 179, 180, 181, 183, 184, 185, 187, 188, 190
magdalenae, Calisius 283, 284, 288, 290, 549
magnifica, Tosia . . 740, 741, 742, 754, 755
magnificum, Astrogonium 742
magnificus, Dipsacaster 755
magnificus, Lonchotaster 755
major, Brentiscerus 45, 55, 56, 78
major, Calisius 282
majusculus, Neuroctenus 532
malayensis, Carventus . . . 295, 296, 298, 299, 549
malayensis, Mastigocoris . . . 513, 514, 549
malayensis, Pictinellus . . . 513, 540, 541, 544, 550
Manatanus 68
mansoni, Ologamasus 205, 210, 211, 213, 215
margarita, Holochila 172, 173
marginata, Banksia . . . 310, 700, 701, 702
marginata, Eucalyptus 492
marginata, Zoila 251, 252, 253, 256
Mastigocoris 514
maugeansis, Haminoea . 329, 330, 331, 334
mayeri, Helicella 84
mcfarlandi, Artabanus . . . 513, 528, 530, 544, 550
mcnamarai, Artabanellus . . 513, 517, 519, 550
m'coyi, Lasiorhinus 383, 390
medius, "Phascolomys" 422, 425
medusa, Heterogamasus (Evanssellus) 497-500, 505-510

PAGE

Megadrymus 41, 46, 74
megalops, Acanthias 791
megalops, Squalus 791
Megaspilus 553, 554
Megastigmus 553
Melaleuca 310
melanocephala, Myzantha 699
melanocephalum, Ceraphron 552
melanocephalum, Copidosoma 551
melanocephalus, Ceraphron 551, 552
melanops, Gliciphila 702
melantatocephalus, Ceraphron . . 551, 552
mellicornis, Anaphes 552
membranacea, Mezira 546
membranacea micronesica, Mezira . . 546
membranaceus, Aradus 546
membranaceus, Brachyrhynchus 546
Meracomelon 84
Mezira 514, 533, 542
Mezirella 533
meziroides, Neuroctenus 533
micronesica Mezira 546
micronesicus, Aneurus 294
micronesicus, Calisius 282
microtheca, Eucalyptus 673
minuta, Acaraptera 305, 549
minutus, Carventus 300
mitchelli, Phascolomys 405, 415
Mizaldus 40, 41, 42, 46, 73, 74
moluccanus, *see* haematodus moluccanus, Trichoglossus
Monosaulax 456
monteithi, Arictus 542
monteithi, Glochocoris 541
montrouzieri, Neophloebia 524
moturikiensis, Pictinellus . . 513 (misspelt), 534, 538, 539, 544, 550
multispina, Nectria . . 465, 467, 468, 470, 472, 476-478, 480-482, 738, 754, 755
multispinus, Crossaster 755
munitus, Chaetaster 468
murrayana, Elsothera 485
muscorum, Achorutes 266
muscorum, Neanura 261, 266
myersi, Acaraptera 303, 305
Myina 552
myomphala, Satsuma 84

naracoortenis, Protochelifer . 757, 760, 763
nasuta, Hyla 711, 712, 714, 718, 720, 723, 724, 726
nasutus, Pelodytes 723
nasutus, Prosympiestus 276
Neanura 261
Nectria 463, 467, 480, 730, 738
neglecta, Helicella 79, 83, 85-87, 483-488, 491, 493, 494
Neophloeobia 523, 524, 525
Nepanthia 749
Nephrurus 189
Nesiaptera 302
Neuroctenus 532
newmani, Achorutes 262
newmani, Lobella 261, 262, 263, 264

PAGE

nigra, Dendrodoris 349
nigra, Doris 349
nigrofrenata, Hyla 711, 724, 726
niphophila, Eucalyptus 231
nitidulus, Neuroctenus 533
notabilis, Calisius 282, 284, 291, 293, 549
Nothofagus 505
cf. novaecaledoniae, Neanura .. 261, 266, 267, 268, 273
novaehollandiae, Phylidonyris 702
nucilis, Ologamasus 205, 210, 220
nuda, Asterias 753
nuda, Uniophora 753, 754, 755
nypelsi, Calisius 282

obesa, Petricia 743, 744
oblongum, Ceratosoma 333
obscurus, Isopeltus 51, 52, 54, 78
obvia, Helicella 85
ocellata, Nectria .. 464-468, 470, 472, 480-482, 738, 755
ocellifera, Asterias 464
ocellifera, Nectria 464, 466, 467, 470, 474, 478-481
ocelliferus, Goniodiscus 464
occidentalis, Parasterina 748, 749
octona, Sabulina 79, 80, 85, 86, 87
Ologamasellus 208
Ologamasus .. 205, 206, 208, 209, 499, 510
Onychiurus 264
Ophiomusium 732
Orectolobus 375
ornata, Banksia 310
ornata, Meliphaga 699
Ornithorhynchus 443, 444, 445
oswaldii, Acacia 673
ovalis, Halophila 732
ovatus, Carventus 296, 298, 299, 549
ovulorum, Myina 552
ovulorum, Mymar 552
ovulorum, Polynema 552
ovulorum, Pteromalus 552
ovulorum, Telenomus 552
Oxychilus 259

pacificus, Calisius 283
pacificus, Regalecus 353
palankarinnica, Perikoala 450, 451
pallidus, Brentiscerus 45, 55, 58, 78
pallipes, Calisius 282
papua, Nyctimystes 357
papuana, Eucalyptus 651
papuanus, Calisius 282
papuasicus, Pictinellus 513, 534, 535, 536, 550
papuasicus, *see* bilobiceps papuasicus, Artabanus
Paracalisiopsis 280, 281
Paradrymus 40, 41, 48, 74
Paragryon 553
Paranepanthia 748
Parasitiphis 206
parkeri, Cophixalus 356

PAGE

parvus, Phascolomys 399, 414, 415, 416, 417
Patiriella 731, 745, 747
cf. paucispinus, Marginaster 755
pectinatus, Astropecten 732, 733, 734, 735, 736, 755
pedicelligera, Nectria 470, 478, 482
penicillata, Meliphaga 699
Pentagonaster 739
pentagonus, Nymphaster 755
peregrinum, Ideobisium 762
Perikoala 449, 451-454
Periseius 206
peroni, Hyla 713
perserrata, Maroubra 791
persimilis, Holochila 166, 168, 169, 170, 171
Petricia 744
Phascolarctos 447-454
Phascolomys 390
Phascolonus 420, 422, 424, 454, 456
Philaemon 356
phillyreoides, Pittosporum 605
Pictinellus 513, 533, 534, 541
picturatus, Appolonius 65
picturatus, Calisius 282
pictus, Amphibolurus 180, 183, 185, 186, 187
pileata, Eucalyptus 700, 701, 702
Pimelia 176
Pinna 751
pisana, Theba .. 79, 81, 82, 85-87, 484, 486, 491-494
placidus, Calisius 282
planus, Isodermus 275
platyrhinus, Phascolomys .. 405, 407, 409, 415
Plectaster 751
Pleuroxia 84
polyacantha, Crimia 526
polyacanthus, Astropecten 736
polyacanthus, Barcinus 526
polyacanthus, Rossius 526
polyplax, Allostichaster 731, 752, 753, 755
polyplax, Asteracanthion 752
polypora, Austrofromia 731, 744, 755
polypora, Fromia 744
porosus, Crocodilus 377
Posidonia 330, 743
Praegliscita 336
praetenera, Doris 347
preissi, Astropecten 733, 734, 736, 754, 755
Propeanura 261, 266
propinqua, Eucalyptus 429
Prosympiestus 276
proxima, Mezira 532
proximus, Neuroctenus 532
Pseudoceraphron 557
Pseudocheirus 448, 449, 450, 454
Pseudophryne 706, 709
Pseudodrymus 42, 69, 74

PAGE

pubescens, Melaleuca 605
pugil, Ideobisium 763
pulchellus, Gamasiphis 206
pulex, Pseudoceraphron 551, 555, 556
punctatum, Cinclosoma 578
putoni, Brentiscerus 55
putoni, Scolopostethus 55
Pythia 496
pyrenoides, Ologamasus . . 205, 206, 209, 210, 222, 223, 224
pyrrhoptera, Phylidonyris 702

quadratus, Appolonius 65

Radix 495
ramsayi, Sceparnodon 420, 422
Ramsayia 456
regius, Lamprius 353
regius, Pleuronectes 353
regnans, Eucalyptus 52
regularis, Allostichaster 731, 752, 753, 754, 755
reini, Chionognathus . . . 29, 30, 35, 36, 37
reinwardtii, Verreauxia 176
reticulatus, Amphibolurus 184, 187
reticulatus inermis, Amphibolurus . . 180, 181, 183, 187, 188
reticulata, Stylasterias 755
retrodrymus 42, 55, 61, 62
Rhizophascolonus 454, 456
Rhodacarus 205, 208, 498
rhysus, Pseudophidiaster 755
robustus, Aneurus 293, 294
robustus, Appolonius 65, 66, 78
robustus, Carventus . . . 298, 299, 300, 549
Rondalesia 57
rosacea, Lobella 261, 262
rosacea, Neanura 265
rosaceus, Achorutes 262
rosselli, Zoila 252
Rossius 526
rossquicki, Aphelodoris . . . 329, 337, 338, 339, 341, 342, 343, 348
ruber, Nannocampus 792
rufogularis, Acanthagenys 699
rugosus, Paphagus 552
rugosus, Stictoteleia 552
runa, Festucalex (Campichthys) . . . 792
runa, Ichthyocampus 792

sabdariffa, Hibiscus 66
saintvincentius, Hypselodoris 332
saipanensis, Calisius 282
salicis, Calisius 281
Salinator 495
salinus, Hydrogamasus 206
saoria, Nectria 463, 467, 468, 474, 478-482, 738, 739, 749, 755
Scelio 554
Sceparnodon . . . 419, 420, 422, 424, 425
schayeri, Astropecten 733, 736
schoetti, *see* hirtellus schoetti, Achorutes
schoetti, Neanura 261

PAGE

Schoinobates . . . 448, 449, 450, 451, 454
schoutedeni, Calisius 282
Scolopostethus 40, 42, 67, 74
Scutus 751
semimarmorata, Pseudophryne . . 705, 707, 709
septimus, Calisius 283, 284, 288, 549
sericea, Adenanthos 702
serratus, Ektopodon 437, 438, 439
serrulatus, Neuroctenus 532
Sessiluncus 208
signifera, Crinia 705
simplicior, Ologamasus 206
sinuatus, Artabanus 526, 530
Sinumelon 84
Siphonaria 495
Smilasterias 752
solida, Salinator 495, 496
solitarius, Pseudotyrannochthonius . . 760
sorrentensis, *see* venusta sorrentensis, Zoila
southcotti, Ologamasus . . . 205, 210, 211, 232, 233
spaldingi, Hyla . . 711, 713, 714, 715, 726
spechtae, Tuckerella 795, 797
spinosissimus, Gamasellus (?) . . 497, 501
spinosissimus, Heterogamasus (Heterogamasus) 497-501
spinulosus, Calisius 283
Spyridium 747
stabilis, Paralaoma 485
stappersi, Calisius 282
stibarus, Pentagonaster 739
Stictoteleia 552
stolismena, Helicella . . 79, 84-87, 483-486
stolonifera, Microcosmus 753
stricta, Casuarina 310, 605
striolatus, Ologamasus 206
stylatus, Chelonoderus 519
Stylogamasus 206, 208
subapterus, Eupteromalus 554
subaustralis, Neodoris . . . 329, 334, 336
subparallelus, Prosympiestus 276
subtriangula, Mezira 546
sulcata, Mezira 546
Sylvadrymus 74
syntomus, Astropecten . . 733, 734, 736
syrphii, Ceraphron 554

Tachyglossus 444
takii, Salinator 495
Taphropeltus 40
tardus, Encyrtus 552
tasmanica, Zosterops 578
tasmanicus, Calisius 283, 284, 287
tasmaniensis, Chromodoris 329, 332, 333, 334
tasmaniensis, Glossodoris 332
tateana, Xanthorrhoea 310
tenera, Haminoea 330, 331
tenuicornis, Isopeltus 50, 54, 78
tenuirostris, Acanthorhynchus 702
terebrans, Telenomus 552

PAGE

terminalis, Serloin 554
terminatis, Homalotypus 554
terraereginae, Megadrymus . . 45, 47, 78
territorialis, Appolonius 45, 65, 66, 67, 78
termitophilus, Aspisocoris 513, 514, 516, 517, 536, 549
tetracanthus, Pteraster 755
tetraporophora, Tympanocryptis 179, 181, 184, 185, 186, 187, 188
Tetrastichus 554
Theba 82, 83, 483
thersites, Zoila 252
thersites contraria, Zoila 253
thomsoni, Phascolomys 401
thoracocera, Mezira 542
thoracoceras, Aradus 541
thoracoceras, Arictus 541, 542
thoracoceras, Brachyrhynchus 542
tigris, Syngnathus 791
tigris, Yozia 791
tindalei, Ologamasus . 205, 210, 211, 226, 230, 231
tinianensis, Calisius 282, 290
tirarensis, Neohelos 436, 458
tornieri, Hyla 719
torus, Kolopsis 458
Tosia 730, 740
trapezia, Anadra 593, 599
Trichacis 553
Tricharius 553
Trichasius 553
Trichopria 554
Trichosteresis 554
tricolor, Neodoris 336
Trigona 621
Trimicrops 554
Trimorus 552
triocellatus, Brentiscerus 45, 56, 59, 60, 78
Triodia 132, 133, 135, 144, 145, 147, 149, 153
triseriatus, Astropecten 733, 735, 736, 737
Tritomacera 68
troglophila, Morikawia . . 757, 758, 760
troughtoni, Nepanthia 731, 748, 755
troughtoni, Parasterina 748, 749
trukensis, Calisius 282
truncatus, Artabanus 513, 527, 550
truncatus, Asterodiscus . . 730, 737, 755
truncatus, Barcinus 533
tuberculata, Crimia 533
tuberculata, Neophloeobia . . 513, 524, 525, 536, 550
tuberculatus, Artabanus 513, 527, 550
Tuckerella 795, 797
tuena, Sathrochthonius 757
turanicus, Calisius 282
Tympanocryptis . . 179, 184, 188, 189, 190

PAGE

uniformis, Tympanocryptis 189
Uniophora 731, 753

validus, Ologamasus 205, 210, 212, 221, 222
valvulatus, Anthaster . . 730, 743, 754, 755
valvulatus, Oreaster 743
vappa, Astropecten 733, 735, 736, 737, 755
varia, Aphelodoris . . 329, 337, 339, 341, 345, 347, 348, 349
varia, Archidoris 337
varia, Doris 337, 347
variabilis, Doris 347
varius, Asteronotus 347
ventrosa, Cochlicella . . 79, 82, 83, 85-87, 483-486, 493, 494
ventrosa, bizona, Cochlicella 83
ventrosa inflata, Cochlicella 83
venusta sorrentensis, Zoila 252
venusta venusta, Zoila 252
vercoi, *see* friendi vercoi, Zoila
vernicina, Asterias 743
vernicina, Petricia 730, 742, 744, 755
verruciger, Calisius 282
vicinus, Neuroctenus 533
victoriae, Acacia 673
virescens, Meliphaga 699
virgata, Helicella 79, 81, 83, 85-87, 484-494
virgosus, Ologamasus . . 205, 210, 233, 234
Vombatus 405, 456
vombatus, Phascolomys 415

wagneri, Rossius 536
weemala, *see* albovenata weemala, Anisynta
wellingtonia, *see* hirtellus wellingtonia, Achorutes
wellingtonia, Neanura . . 261, 266, 268, 269
wilsoni, Mezira 513, 542, 543, 550
wilsoni, Nectria 466, 467, 474, 480, 481, 482
Wisteria 171
Wombatula 392
womersleyi, Neanura 261, 270, 271
woodwardi, Mizaldus 39, 43, 78
wotjulumensis, Hyla . . 713, 714, 715, 718, 724, 726

Xanthomelon 84
xanthospilos, Candalides 166

zebra, Astropecten 735
Zoila 252, 253
zonata, Morikawia 759
Zostera 330, 742
Zosterops 577

NATIONAL MUSEUM OF VICTORIA

Sim-B37

51084